PRODUCTIVITY IMPROVEMENT IN MANUFACTURING INDUSTRIES

(Case study of Del Monte Kenya)

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

BY

NAMISI M. SOLOMON

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTERS DEGREE IN INDUSTRIAL ENGINEERING AND MANAGEMENT AT DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

JANUARY 2014

Declaration

I declare that this thesis is my original work and has never been presented to this institution or to any other institution for examination or for any other purpose.

Name: Namisi Masungo Solomon Sign: ________ Date: 09/04/14

Certification

I certify that the above-mentioned student carried out the work detailed in this report under my supervision.

Name: Dr. Peter Muchiri Sign: ________ Date: 9/04/2014.

Name: Prof. L. Gelders Sign: ________ Date: ________

DIRECTOR
NAIROBI CAMPUS
DEDAN KIMATHI UNIVERSITY
OF TECHNOLOGY

Dedication

To my father Earnest Namisi and my dear wife NoellaMasungo

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Acknowledgement

I thank the Almighty God for the good health, energy and guidance through the whole process of my proposal work.

I would like to acknowledge the support of my supervisor Dr. Peter Muchiriand the University as a whole for the guidance through the whole process from course work study through proposal development by ensuring that that I maintain quality work.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Abstract

The basic goal of manufacturing industries is tomaximize profitability in order be competitive and stay in the market. This is mainly achievedby producing products at low cost to maximize profits. However,low productivity has been the major problem facing most manufacturing companies just like DMKL. Two major sections that are affected by low productivity in DMKL processing plant are Labeling and Parking section. Productivity in these sections stand at an average of 50% the rated capacity hence need for productivity improvement.This is attributed by many factors, which include low equipment performance, equipment unavailability, ineffective resource utilization and production wastes. This has largely contributed to increased production costs, decline in production thus difficulties in meeting targets and customer demands.The problem at hand that needs to be addressed is low productivity at DMKL processing plant.

The purpose of this study was to explore the factors affecting productivity in manufacturing industries and determining strategies to improve productivity.This was achieved by investigating the impact of various variables affecting productivity,which include equipment performance, equipment availability and production wastes.Data that were used for analysis included Secondary data,primary data and documentary data. The data was subjected to a regression analysis to determine the influence of various factors on the productivity in the processing plant. The causal factors behind low productivity were explored through root cause analysis techniques like Pareto charts, 5 ‘Whys’ and Ishikawa diagram (fishbone). Decision tree analysis was used to determine beststrategies for productivity improvement which were evaluated before recommending an optimal strategy.

It was found out that equipment availability and performance significantly affects productivity and identified equipment breakdown, power failure, bottlenecks and reduced speed as the root causes of equipment unavailability and poor performance. Similarly inventory was found as a major factor hindering productivity and its root cause identified as highproduction cost due to increased production waste. It was identified that by applying and implementing Total Productive Maintenance (TPM) and Lean manufacturing System, equipment breakdowns, bottlenecks and production cost are reduced which significantly improves productivity. Similarly, investing in a cost effective green energy power plant like Bio-mas plant would solve the problem of power failures.From this study, manufacturing industries can use the result to help identify the factors that affect productivity by using decision tree analysis to establish the best strategies to improve productivity.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Contents

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

List of figures

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

List of tables

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

CHAPTER ONE

1.0 Introduction

1.1 Background

Improvement of productivity in manufacturing industries has been important since the start of industrialization in Kenya and there are no signs that this competition will ease. With continuous increase of global competition between manufacturing industries against demanding market, there is need for manufacturing industries to maximize profit in order to be competitive and stay in the market. As a result manufacturing companies try to redefine, redesign and improve their production system to meet the competitiveness demanded by the challenges of present market (Dangayach at el 2001). As noted by Grunberg (2003), this increased competition creates an ever greater need for fast-rate improvement methods that can sustain competitiveness. Huang et al (2003) also states that due to intense global competition, companies are striving to improve and optimize their productivity in order to remain competitive.

The Manufacturing sector form a major part of the Kenyan economy contributing about 14% of the gross domestic product (GDP), they come second after agriculture contributing about 27% of the GDP (Economic survey 2007). Manufacturing industries also generate both direct and indirect employment and therefore for sustainability of country’s economy, these industries need to be natured and sustained against the global competitive market. Therefore, the development of this sector is significantly important for any country irrespective of the level of development. However, the manufacturing sector in Kenya is faced with many challenges including poor performance and low

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

productivity. As noted by Njiraini et al (2012), improvement of productivity is key to success of most organizations as it benefits both the investor and the employee.

Productivity is an economics term which refers to the ratio of product output to product input hence it is a measure of how well resources are utilized. It also measures the rate at which outputs of goods and services are produced per unit of input (labour, capital, raw materials). Depending on the context and the selection of input and output measures, productivity calculations can have different interpretations. Conceptually, productivity is a ‘supply-side’ measure, capturing technical production relationships between inputs and outputs. But, implicitly, it is also about the production of goods and services that are desired, valued and in demand. Increase of productivity occurs only if for the same level of input or less the output increases.

Productivitygrowth is important in any profit making organization since it helps to improve the overall performance of the organization. Productivity growth means more value is added in production and this means more income is available to be distributed. In manufacturing industries, the benefits of productivity growth can be distributed in a number of different ways which includes better wages to the workforce, increased profit to shareholders and lower prices to the customers.At the national level, productivity growth raises living standards because more real income improves people's ability to purchase goods and service, enjoy leisure, improve housing and education, and contribute to social and environmental programs. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Improvement of productivity is the key to success in all manufacturing industries.Since manufacturing industries in Kenya is among the country's key pillars of economic growth in both Growth Domestic Product (GDP) and employment level, there is need for productivity improvement. This will help to attain the Kenyan's development plan dubbed vision 2030 and improve the overall living standards.Improving productivity can have a positive change on the use of inputs especially when adopting efficient production processes that minimizes waste. This will help any organization to remain competitive and sustainable. Equally, improving productivity can have an implication of yielding more output especially when using resources in activities or with technologies that generate more output.

There are many factors whichinfluence productivity and therefore organizational competitiveness and growth is basically determined by its productivity level. Some of the factors that influence productivity include technology, people, and management practices (Anderson CA 1996). There exist three types of productivity as identified by Kendrick as single factor productivity, multi-factor productivity and total productivity. Single factor productivity is a ratio of outputs to one type of input (Lema, 1995). For example, labor productivity is the ratio of outputs to labor input. Similarly, capital productivity is the ratio between outputs and capital input while Multi-factor productivity is the ratio of net output to the sum of associated labor and capital input. Consequently, total productivity is the ratio of total outputs to the sum of all input factors. Thus, total productivity measure reflects the joint impact of all the inputs in producing the outputs (Lowe, 1987).

Del Monte Kenya limited was selected as a case study in this research to represent manufacturing industries in Kenya since it is involved in production process.This process

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

involves the conversion of raw materials into finished products through mechanical process with a view to enhance the value of utility of the product.

Company background

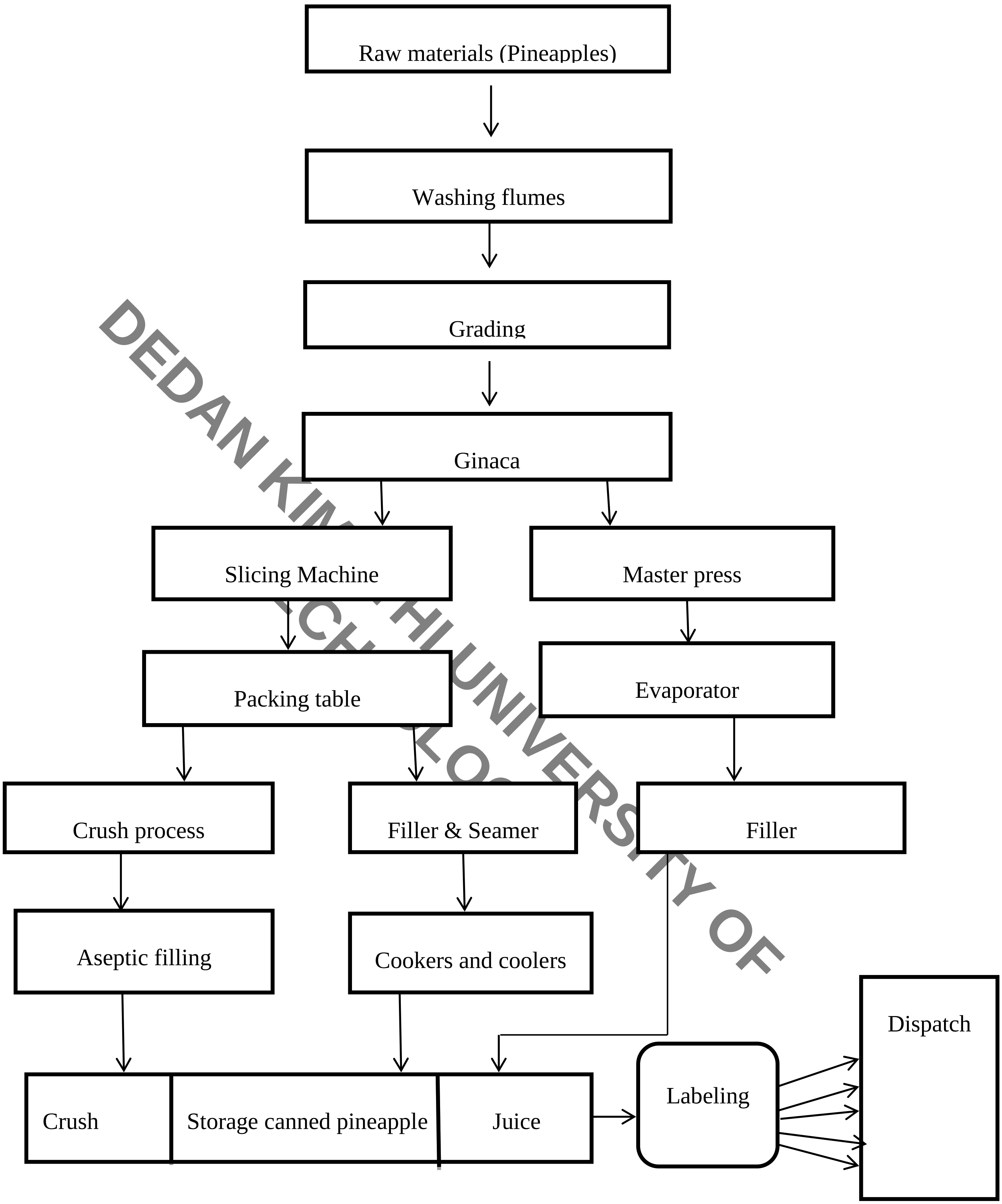
Del Monte Kenya Limited (DMKL) is a multi-national food manufacturing company that produces canned pineapple products, industrial pineapple products and beverage juice. It provides 100% of Del Monte Europe, Middle East and Africa's pineapple products. Its operation runs for 24 hours per day in 3 shifts with an expected daily throughput of 1500 metric tonnes. Canned pineapple being the main product packed in the plant representing 90% while industrial pineapple product and beverage juices constitute to merely10%. The company processes an average of 17500 cases of canned product daily compared to 320 drums of concentrates and 6500 cartons of beverage juice. (DMKL database)

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

The overall operation of the organization starts from plantation which is the source of raw materials (pineapples). The pineapples pass through a washing flume and graded before being elevated to Ginacas for fruit pilling. The main fruit is then sliced ready for packing in empty cans and then filled and sealed before passing through cookers and coolers. They are finally palletized and stored ready for labelling before dispatching the canned product to the market. Beverage juice and industrial pineapple product at the same time areextracted from broken slices, the core, ends and pineapple skin by a master press before passing through an evaporator. Concentrates are then filled in drums and stored in cold room ready for dispatch while the beverage juice is also prepared ready for market.

The company process its canned product to store as its operation strategy since the raw materials are seasonal and the demand varies with the season. The ordersalso come at random with different brands and different labels to suit individual customers hence justifying this type of operation approach. This has made labelling section as the pivot point and bottleneck of operation where several customer demands converge. For the organisation to satisfy random and non-uniform customer need effectively, the efficiency of both sections of operation need to be superb at all times.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY



DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Figure1.1 DMKL Process flow

1.2 Problem environment

Productivity improvement is the core aspect of manufacturing industries. It aims at producing products and services at low cost of production in order to maximize profits. Most companies in Kenya just like Del Monte face problems of low productivity and high operation cost. Two major sections that are affected by low productivity in DMKL processing plant are Labeling and parking (cannery) section.Labeling section in DMKL is the bottleneck of operation since it is the pivot point at which majority of the product pass through before dispatching to various customers. Based on various orders from different customers for different brands and labels in a non-uniform format, there is need for this section to be above board in both effectiveness and overall efficiency. This is becauseit is at this point where the customer comes in contact with the organization. However, the current labour productivity level in DMKL labeling section stands at 8.5 cases per man hour against a target level of fifteen. This only represents 56.67% of the rated capacity hence need for productivity improvement in this section. Consequently the operation cost per case is rated at average of Ksh30.00 against a target of Ksh 21.00 (DMKL database).This basically indicates that the operation cost is indeed higher than expected.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

The parking section which involves sorting and parking is very vital since this is the point where the quality of the product is determined. However, the current production cost per case exceeds the target by 20%.Spoilage/waste at this section is at an average of 0.5% against 0.25% of total production (DMKL database). At the beverage plant, both quality and efficiency is the key to success of the whole system, and yet the percentage spoilage/waste of the total production is at average of 5% against a target of 3%. While the production cost per case exceeds the target by an average of 15% (DMKL database). Improving the operation of these sections will have a significant positive impact on both a customer-company relationship and sustainability the whole organization in the volatile and competitive market.

The major identified causes of the problem based on past studies include machinery/equipment breakdown, labour,lack of materials, poor leadership/managementstyle, rework and poor facility layout (Anderson CA 1996). Njiraini et al (2012) also identified five major causes that contribute to low productivity in Small medium enterprises which were grouped into 5M's (Machine, Methods, Men, Materials, and Measurements). Fig 1.2 shows the cause and effect diagram.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

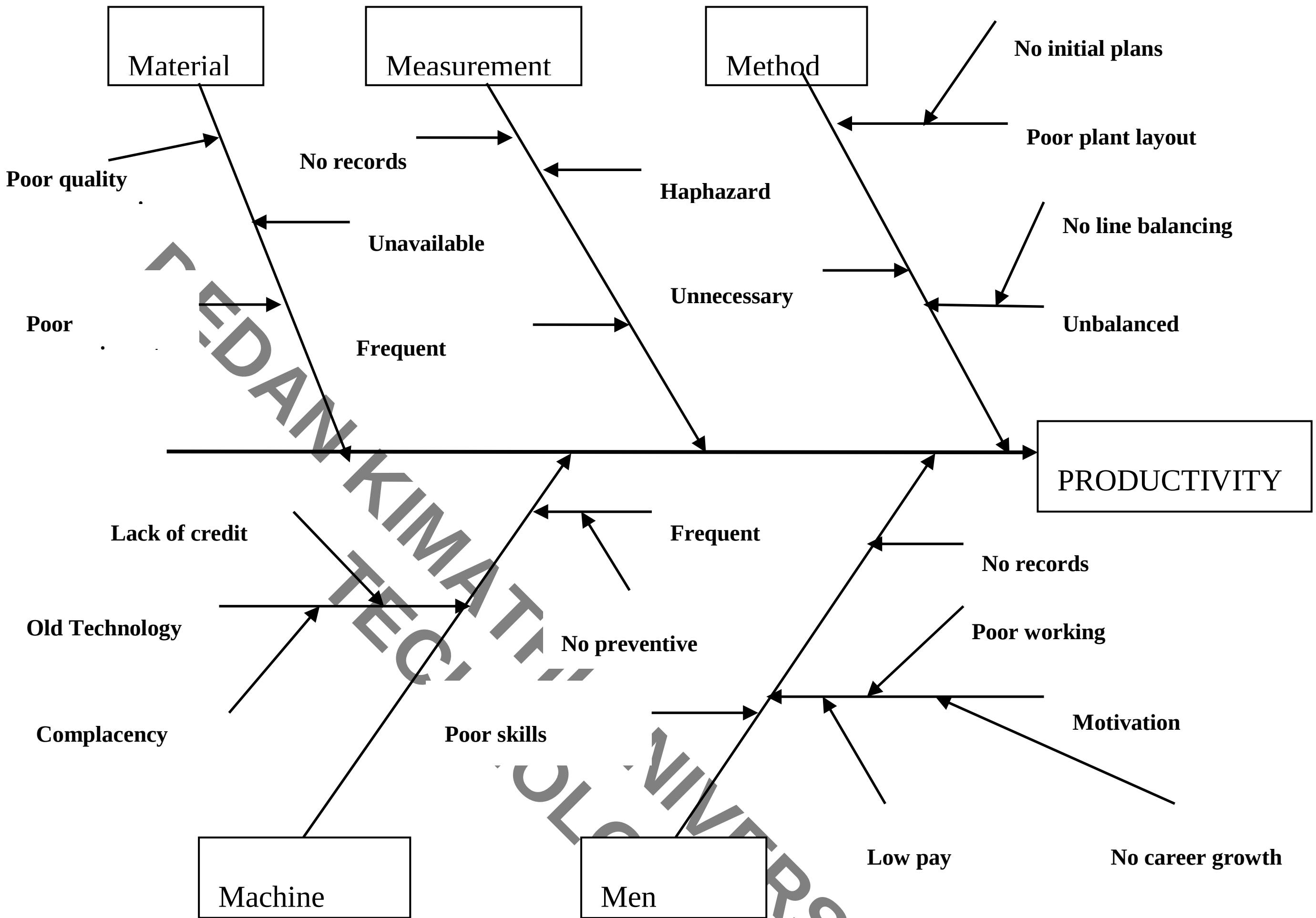


Fig 1.2 Cause and effect diagram

Low productivity due to a combination of these factors contribute to increased production costs and decline in production, thus resulting in difficulties in meeting production targets and customer demands. However based on preliminary pilot test conducted in DMKL by the researcher, the Pareto analysis identified the vital few factors which were categorized into two major groups i.e. Machines and Materials which needed to be investigated in order to understand its significance and how they affect productivity.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

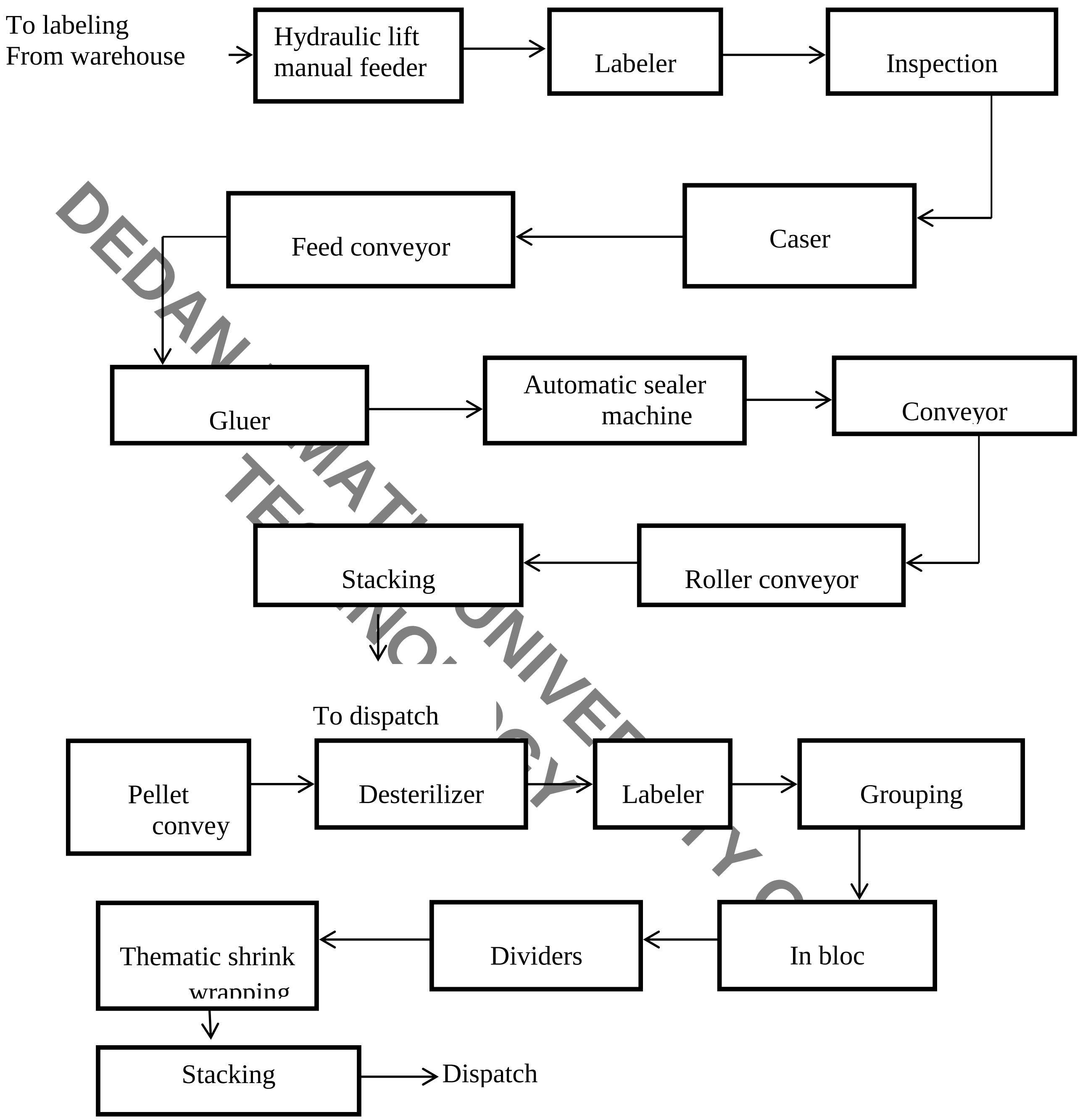


Figure 1.3: Flowchart in the labeling section

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

1.3 Problem statement

Most companies like Del Monte Kenya need to attain profits for them to manage remaining in the market,however, the cost of production have been increasing with time. This is due to declining productivity making it difficult to meet production targets hence demanding for unnecessary overtime and rework that has pushed operation cost to the brim. In the long run, the company may not be able to sustain these increased costs which can push them out of business due to unprofitability. The problem at hand that needs to be addressed is low productivity at DMKL processing plant.

By improving productivity in this plant, the current level of productivity can be surpassed and not only reduce operating cost but also more available income for sustainability and development. Given this foregoing situation, a study on how to improve productivity in manufacturing industries citing DMKL as a case study is important. By investigating specific variables affecting productivity and determining strategies to improve productivity will be the major purpose of this study.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

1.4 Objectives

The purpose of this study is to explore the factors affecting productivity in Del monte Kenya and determining strategies for productivity improvement.

The specific objectives are to;

i. Determine the factors that affect productivity in DMKL plant.

ii. Determine the root causes of low productivity in DMKL plant.

iii. Determine strategies for productivity improvement.

1.5 Research questions

i. What are the factors that affect productivity in DMKL plant?

ii. What is the root cause of low Productivity in DMKL plant?

iii. What strategies can be employed to improve productivity?

1.7 Justification

Interventions that will improve productivity in food manufacturing companies would contribute to reduced cost of operation, sustainable customer demand and satisfaction that is needed to achieve sustained profit growth and ensure the company stays top in the competitive market. This study will not only contribute to better living standards and high earning potential which strengthens the overall economic empowerment but also improve efficiency.

1.8 Limitation of the study

The study involves numerous data that is produced which cannot all be subjected to analysis thus only a section of the data will be used to act as a representation of all the other sections. The data may not give a true picture of the real situation. The company may not allow its name to be published and be shared with other similar companies which might benefit from the study due to confidentiality issues. The findings may not beimplemented due to resistance to change for the fear of the unknown.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

1.9 Scope of the study

The study was carried out on Del Monte Kenya production plant (parking section and labeling section) to attain the objectives of this study.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

CHAPTER TWO

2.0 Literature review

2.1 General overview of productivity

Productivity is an economics term which refers to the ratio of product output to product input hence it is a measure of how well resources are utilized. It also measures the rate at which outputs of goods and services are produced per unit of input (labour, capital, raw materials,) (Zandin, 2001). Productivity is the only measure of competitiveness in manufacturing industries (Khurana et al 1998).Therefore the need to improve productivity is vital in manufacturing industries. There is a range of research studies taken place across the world to improve productivity and this paper focuses on such efforts in manufacturing companies focusing on Kenya.

Improving productivity is a major concern of any profit-oriented organization as representing the effective and efficient conversion of resources into marketable products and determining business profitability (Wilcox et al, 1993). Consequently, considerable effort has been directed to understanding the productivity concept, with the different approaches taken by researchers resulting in a wide variety of definitions of productivity (Wilcox S., 2000).

Due to the importance of maximizing productivity of an organization, many scholars and researchers have directed their efforts towards understanding the factors that drives it. Anderson (1996) defines productivity as a comparison between how much is put into a

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

system in terms of man-power, material, machinery or tools and the output from the system. He observes that Productivity has to do with the efficiency of production, hence more productive system yields more output for less cost, in less time, with fewer workers.

There is a big confusion between productivity and production. Gupta et al (2000) in his paper, argues that productivity is not necessarily increased by increasing production. This is because Production work denotes the outputs only without any reference to inputs while productivity is concerned with the effective and efficient utilization of resources (inputs) in producing goods or services (outputs). If viewed in quantities terms, production is quantity of outputs produced, while productivity is the ratio of the outputs produced to the inputs used.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

2.1.1 Types of productivity

Kendrick identified the three types of productivity as single factor productivity, total factor productivity and total productivity.

Single factor productivity

According to Lema (1995), Single factor productivity is a ratio of outputs to one type of input. For example, labor productivity is the ratio of outputs to labor input. Similarly, capital productivity is the ratio between outputs and capital input.

On the other hand, Lowe (1987) argues that single factor productivity is widely used as a measure of economic efficiency. The researcher goes ahead and observes that it is commonly used for economic analysis because of its simplicity. However, it suffers from a weakness in that it does not include the total productive process and it does not adequately deal with the impact of technological change and factor substitution.

As mentioned earlier, the two types of single factor productivity are labor productivity and capital productivity. Labor productivity is the most widely used yardstick of operational efficiency. This does not imply that labor is the best-input element for productivity measurement but simply reflects the difficulty or impossibility of obtaining numerical values for the other determinants of productivity (Lowe, 1987).

On the other hand, capital productivity is usually defined in terms of a percentage return on capital invested, either using a traditional method such as average rate of return or a discounted cash flow method such as the internal rate of return method (Lowe, 1987).

Multi-factor Productivity

To overcome the limitations of the single factor approaches considered above the Multi-factors productivity measurement was developed. Multi-factor productivity is the ratio of net output to the sum of associated labor and capital input (Lema, 1995). Heizer (1990) represented it mathematically as shown below:

$$TFP = \frac{Output}{(H_t + C_t)}$$

Where *TFP* is the total factor productivity, H_t is the human input factor while C_t is the capital factor input.

From the point of view of productive efficiency under conditions of scarcity, an enterprise will have to combine the various inputs in the correct combination for optimal results

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

either to minimize costs for a given level of production or to maximize production from available resources. From the point view of allocated efficiency, the owners of the various factors of production may be assumed to seek to maximize their return from those factors (Lowe, 1987).

Total productivity

Total productivity is the ratio of total outputs to the sum of all input factors. Thus, a total productivity measure reflects the joint impact of all the inputs in producing the outputs (Lowe, 1987). Mathematically, it can be represented as shown below

$$TP = \frac{Total\ output}{Total\ input} = \frac{V_t}{H_t + C_t + M_t + O_t}$$

Where V_t is the total output, H_t in the human factor input, C_t is the capital factor input, M_t is the material factor input and O_t comprises all other factors.

2.1.2 Productivity variables

According to Heizer (1990), productivity increase exists because of the management of three variables. These productivity variables are labor, capital, and management. These three factors are critical to productivity improvement. They represent the broad areas in which managers can take action to obtain better productivity.

The quality of labor is the first variable of productivity. Three traditional variables for improved labor productivity have been identified. They are basic education appropriate for an effective labor force, diet of the labor force, and social overhead that makes labor

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

available, such as transportation and sanitation (Heizer J., 1990).

Capital investment, the second variable of productivity, provides those tools. These tools can range from desk computers to complex machinery and new airports (Heizer J., 1990). Production can often be accomplished with some trade-off between labor and capital. That is, if we want to build a road we can do so with crews of thousands using shovels or we can invest in earth moving equipment. The trade-off between capital and labor is continually in flux.

Management is the last variable of productivity of any given organization. It is responsible for insuring that labor and capital are effectively used to increase productivity. The arts and sciences of management include improvements made by technology and knowledge. Such improvement requires training and education.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

2.2 Factors affecting productivity

General overview

There have been several approaches to the classification of the factors affecting productivity in the manufacturing sector. The following examples illustrate some of approaches to the classification of productivity factors.

A United Nations (1965) cited by Lema (1995) report stated that, in ordinary situations, there are two major factors affecting site labor-productivity requirements: organizational continuity and executional continuity. Organizational continuity encompasses physical components of work, specification requirements, and design while executional continuity relates to work environment and the efficiency and effectiveness of job organization.

Thomas (1991) added a third class of factor affecting productivity- the Management aspects. Management aspects include weather, material and equipment availability, congestion, and out-of-sequence work.

On the other hand, Kane et al (1980) classified factors affecting manufacturing productivity into two main groups: technological factors and administrative factors. The technological factors encompassed those related mostly to the design of equipment while the administrative factors are related to the management of the organization. However, Olomolaiye et al (1998) stated that factors affecting productivity are rarely constant and may vary from country to country, from organization to organization, from equipment to equipment and even on the same equipment depending on the circumstances.

The factors affecting productivity indeed vary from country to country, since Wachira (2001) listed unfair wage balance, recruitment of unskilled personnel, poor communication between supervisors and employees, late deliveries of materials and equipment, lack of motivation, poor welfare facilities, lack of training and lack of investment in research and development as factors that influence labor productivity in Kenya. However the author only concentrated on exploring factors affecting productivity in construction industries and not manufacturing industries.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

2.2.1 Equipment performance and availability

A study of the factors affecting productivity, whether positive or negative is necessary for productivity improvement. In order to eliminate or control those factors that affect productivity negatively and making use of those which have positive impact (Lema, 1995). Several researchers have investigated the factors affecting productivity. Despite such intensive investigation, researchers have not agreed on universal set of factors with significant influence on productivity. Therefore as earlier mentioned, it is argued that factors affecting productivity are rarely constant and vary from sector to sector (Olomolaiye et al 1998).

However, Fleischer et al (2006) noted that the competitiveness of manufacturing companies depends on the availability of their production facilities. He further argues that the equipment of highly integrated production facilities, with robust components and surveillance functionality combined with the right service elements contributes significantly towards securing this availability. In this context, there exists an urgent need for research to explore the impact of equipment performance and availability on productivity in Kenyan manufacturing industries.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Performance of equipment is achieved by comparing the production per unit time to the rated capacity of equipment; it is always affected by minor stoppages and reduced speed of equipment. While availability is identified as the period of time in which the machine can actually be used for production purposes.it is affected by equipment failure, setup and adjustments. Operational availability in that sense takes into account times of technical, administrative organizational and logical disruption of production (Fleischer et al 2006).

In the Toyota system, there are two words that have very specific meanings: process and operation. Process is the course by which material is transformed into product. This consists of processing, inspection, transport and storage. Operations are the actions performed on the material by machines and workers (Shigo, S. 1989). He further identifies that the most efficient way to improve set up operations is by using SMED.

There are two types of set ups according to Shigo, S. (1989); internal which can only be performed when the machine is stopped and external which can be performed while the machine is running.

2.2.2 Production wastes

In the present highly competitive business environment, well run organizations continually strive to enhance their capabilities to create excellent value for the customers by improving the cost effectiveness of the operations. Significant improvement as taken place in the management of resources associated with manufacturing systems, to reduce the wastage of resources. A great number of companies find that in spite of huge improvement in productivity, there is still a bigger and better potential to utilize machine tools and reach better productivity goals. (Karuppana G. et al 2013).

Ohno T. (1988) identified that production system relies on elimination of waste as essential. The preliminary step of the Toyota production system is to identify the wastes which includes; overproduction, waste of time, transportation waste, processing waste, inventory and making defectives. He further argued that eliminating these wastes completely can improve operation efficiency by a wide margin. Wacker et al (2006) states in their review that investment in both human and equipment resources will improve plant efficiency and manufacturing productivity. However, investing in human and equipment only without utilizing them can prove to be a big challenge in improving productivity. According to Vilasini et al (2012), ineffective use of resources (equipment, workers, material) was the main factor hindering productivity in Sri Lankan

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

manufacturing industries. This study will therefore investigate the effect of resource utilization on productivity in Kenyan manufacturing industries.

There are seven types wastes in a production system (Shigo 1989).

- Overproduction
- Delay
- Transport
- Processing
- Inventory
- Wasted motion

Eliminating these wastes completely can improve operation efficiency by a wide margin and therefore action to eliminate them is essential.

2.2.3 Strategies for improving productivity

Several authors have come up with strategies to improve productivity in manufacturing industries. For instance Shigo (1989) concluded from his study that elimination of waste of over production cannot be achieved without SMED (single minute exchange of dies), which must be achieved in order to be able to respond to changes in consumer demand. He further points out that the most effective way to improve set up operations is using SMED. There are two types of se ups according to Shogo (1989); internal which can only be performed when the machine is stopped and external which can be performed while the machine is running. He also notes that in order to improve productivity; process improvement must be done before attempting to improve operations.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Ohno T. (1988) noted in his study that many companies try to improve productivity through industrial engineering; Ohno (1988) however, noted that industrial engineering is meaningless unless it involves cost reduction and increased profit. He further notes that improving the methods of manufacturing should not only include large-scale capital investment plans, but also work simplification to reduce the number of workers needed to complete a job.

The Japanese concept of continuous improvement (Kaizen) integrates scientific and humanistic management philosophies as it is the primary process for ongoing improvement of quality of life of all individuals by focusing on areas such as recognition, autonomy, training and development of individuals (Chaser,1994). Gunaseka et al. (1994) noted that in order to improve productivity, most companies began to initiate new concepts such as Total Quality Management (TQM) and Just –In-Time (JIT). These new concept are not limited to the car manufacturers but also widespread among other suppliers.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

During the last two decades, productivity research and application have not been given adequate importance when trying to attain excellence in the management of manufacturing enterprises (Murugeshet al. 1997). Grunberg (2003) has identified such an initiative to improve the manufacturing productivity on the start of industrial era. According to Njiraini et al. (2012), a study showed that the different productivity improvement techniques can be categorized into five groups; technology, material, employee, products, and processes. He further states that many firms have developed a strategies and adopted policies and mottos such as ‘you cannot improve what you can’t measure’ to steer their organization to a higher level. In order to improve productivity, European countries began to initiate the methods of the Japanese and introduced new concepts such as Total Quality Management (TQM) and Just –In- Time (Gunasekaran et al. 1998). However, Tajiri et al. (1992) in his study states that although Total Quality Management (TQM) is widely adopted by many firms in their effort to increase organizational capabilities, the payoffs from this program have often been limited because of unreliable or inflexible equipment hence importance to include the maintenance management into a totality concept.

Swanson (2001) sates in his study that implementing maintenance strategies which has come into play of manufacturing industries such as Total Productive Maintenance (TPM), Kaizen, 5 S, Lean and Six Sigma requires better level of training and sufficient amount of resources to provide high level of performance in the plant and equipment. Womack et al. (1996) explains that implementation of such improvement strategies in the west was often not fully successful and this is still the case.He further asserts that most western companies are still 'traditional' mass production companies. However, the development of such methods in Japan did spark a new improvement method as a competitive counteraction against the Japanese movement like Theory of Constraints (TOC) and Business Process Improvement (BPI) (Grunberg 2003).He further explains that each of these methods has a particular background and was developed to solve particular forms of improvement problem or problems within particular contexts. TPM, TQM and lean manufacturing focus on the reduction of waste but within holistic consideration of the big picture (Gunasekaran et al 1998). The only one of these methods that prescribes where to start to look for improvement is Theory of Constraints (TOC) (Grunberg 2003).

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

The old models of productivity improvement strategies do no longer perform because of the technological advancement and competitive environment of the business world (Dilanthi 2013). He furthers argues that in order to achieve the competiveness and other goals of an organization, it is very important to the workers to be in line with the forthcoming trends and techniques of the business world. Strategic formulation is the course of action companies take to achieve their d3efined goals and enables companies to evaluate resources, allocate budgets and maximize return on investment.

Performance measurement

Performance measurement is important in production system management. Performance measures provide an important link between the strategies and management action and thus support implementation and execution of improvement initiatives (Gregory et al 2005). Metrics for measuring and analyzing the productivity of measuring facilities have been studied for several decades. Karuppana G. et al (2013) stated that measurement is needed for identifying the problems in order to improve productivity. To achieve this, it is necessary to establish appropriate metrics for measurement purposes (Nachiaappan et al 2006).

Productivity is critical for continuous competitiveness and profitability of any organization. It can be effectively raised if it is managed holistically and systematically. Measurement of productivity is a prerequisite for improving productivity since it helps to achieve the set targets and objectives hence making an organization or business to have controls. Measurement plays a very vital role since it determines if an organization is progressing well or not. It provides information of how well the resources are effectively

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

and efficiently utilized. Productivity is the ratio between the output and the input. Essentially, productivity measurement is the identification and estimation of the appropriate output and input measures. Outputs could be in the form of goods or services rendered which may be expressed in either physical quantity or financial values. While the input comprises of resources used to produce output, the most common form of input are labour and capital.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

The most common measure of productivity in most industries is labour and capital productivity (Njiraini at el 2012). Labour productivity which is defined as value added per worker. It defines effectiveness and efficiency of labour in the production and sale of the output. Capital productivity measures the effectiveness and efficiency of capital in generation of output. This is the value added per dollar of capital. Capital productivity results from improvement in the machinery and equipment used, as well as the skills of the labour using the capital and process (Lowe 1987). Similarly DMKL uses production cost per case; percentage spoilage; net tones per plant hour; cases per man hour as the Key performance indicators to measure productivity. However, according to Huang et al (2003), he views that traditional productivity metrics, such as throughput and utilization rate, are not very helpful for identifying the underlying problems and opportunities for productivity improvement. He further argues that these metrics only measures part of performance of manufacturing equipment. This situation has led to the need for more vigorous productivity metrics that are able to take into account several important factors such as equipment availability (breakdowns, set-ups, and adjustments), performance (reduced speed, idling and minor stoppage) and quality (defects and rework). Due to intense global competition, companies are striving to improve and optimize productivity in order to remain competitive (Huang et al 2003). In his study,Muchiri (2006), views that this improvement would be possible if production losses are identified and eliminated so that the manufacturers can bring their product to the market at a minimum cost.

Huang et al (2003) stated in his study that the total productive maintenance (TPM) concept, launched by Seiichi Nakajima (Nakajima 1998) in the 1980s, has provided a quantitative metric called overall effectiveness (OEE) for measuring the productivity of individual production equipment in a factory. The concept of OEE is becoming increasingly popular and has been widely used as a quantitative tool essential for measurement of productivity in semiconductor manufacturing operation. (Huang et al 2003).

Overall equipment efficiency (OEE)

Different scholars have come up with different ways of representing OEE, but with the same interpretation. According to Marcello Braglia (2008), OEE is a ratio between what is actually manufactured and what could have been ideally manufactured or as a ratio between the time in which the equipment works and the full operating capacity of the equipment. This concept can be formalized as shown below

$$OEE = \frac{output\ output}{reference\ output}$$

$$OEE = \frac{cycle\ time * valuable\ operating\ time}{cycle\ trime * loading\ time}$$

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

$$= \frac{valuable\ operating\ time}{loading\ time}$$

Where loading time is the actual available time for operations and valuable operating time is a fraction of time in which a production line works under optimal working conditions (Marcello Braglia, 2008, p. 6).

According to Muchiri (2006), OEE is a function of the availability of the machines (A), performance of the machines (P) and the quality rate (Q). Figure 1 below shows the main components of OEE

DEDAN KIMATHI

Figure2.1: components of OEE

$$OEE = A * P * Q$$

The above equations shows that OEE as a tool has integrated all the important aspects of the manufacturing process into a single tool. These are the quality efficiency, the maintenance effectiveness and the production efficiency.

The inverted staircase shown in figure 2 below shows how different elements affect the effectiveness of the equipment (Huang S.H., 2003, p. 20).

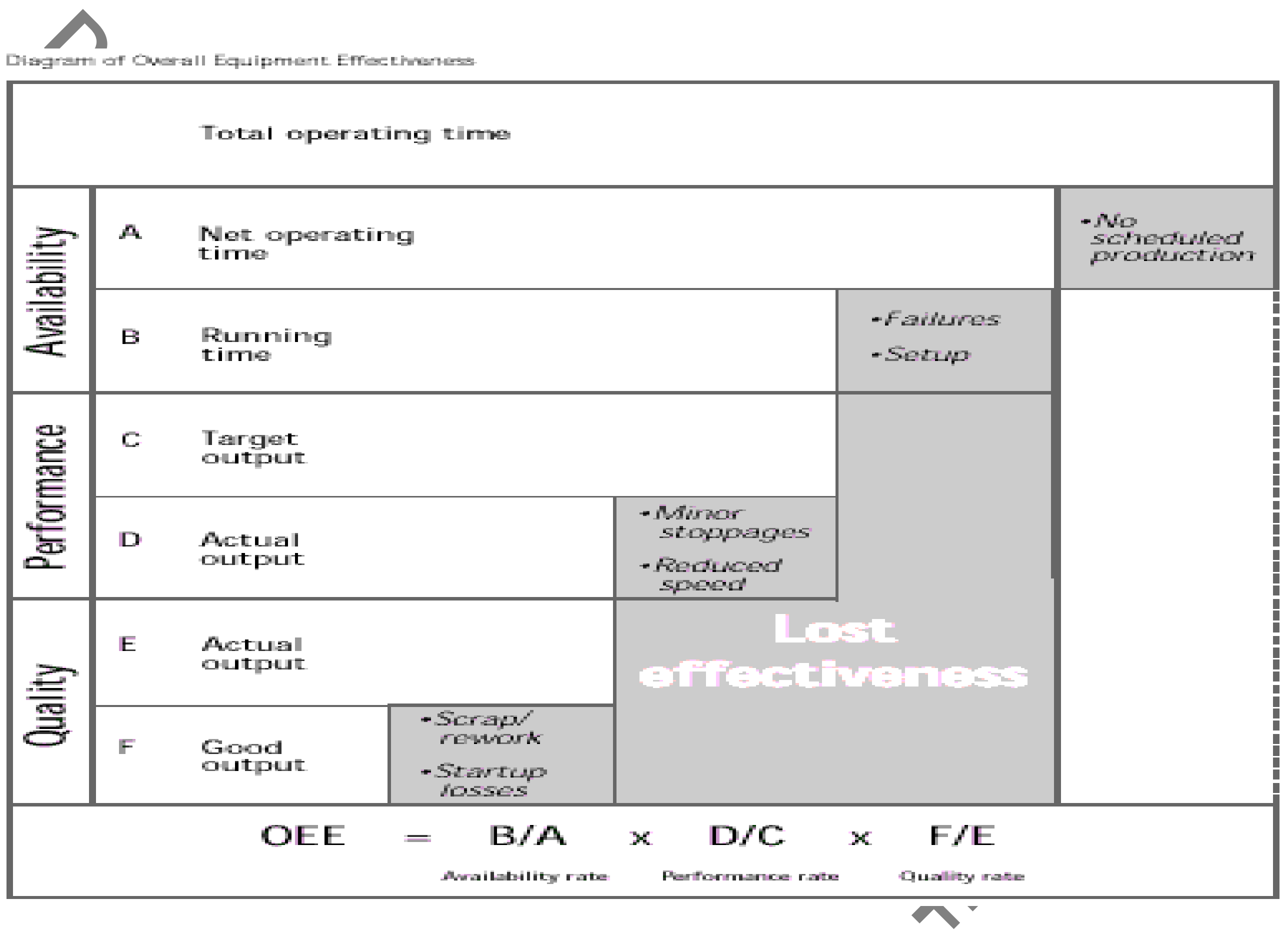


Figure 2.1: Inverted stairs showing lost effectiveness in equipment

Total Equipment Effective Performance (TEEP)

Unlike OEE, TEEP encompasses an aspect of distinguishing unplanned downtime and planned downtime; the objective being reducing unplanned downtime. As such, it has elements such as the MTBF and MTTR. The maintenance department either reduces MTTR or increases MTBF so as to increase the overall availability of the production line. The TEEP measure, like OEE, is limited to equipment-level productivity (Muchiri, 2006).

Production Equipment Effectiveness (PEE)

Different elements have different contributions to the productivity of a production plant. As a result, the three different components of OEE (availability, performance and quality) are given different weights before an analysis begins. PEE also makes a distinction between two different types of production operations namely, discrete-type production operations and continuous process operation (Rouf, 1994):

For discrete-type operations, PEE is calculated as shown below:

$$PEE = (A^{k1})(E^{k2})(Q^{k3})$$

Where A is the availability, E is the performance efficiency, Q is the quality efficiency while ki is the weight of the PEE elements.

For continuous processes, PEE is a function of availability (A1), Attainment (A2), Performance efficiency (E), Quality level (Q), operating utility (OU) and product support efficiency (PSE). It is given by the following equation

$$PEE = (A1^{k1})(A2^{K2})(E^{K3})(Q^{K4})(PSE^{K5})(OU^{K6})$$

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Overall factory effectiveness

OFE was developed to measure the factory level effectiveness where several production machines are installed to form a production process. While OEE is about achieving excellence in individual equipment, OFE is about the relationship between different machines in a production line. OFE thus tries to synchronize the production process with planned downtime, setup time, changeover time and capacity scheduling.

Overview of global causative of low productivity

Lack of material happens to be the man factor reducing productivity in Indonesia. Olomolaiye et al (1996) also compared productivity problems in Indonesia with other countries obtained from literature. The results are as shown in table 1 below.

Table 2.1: Comparing Productivity problems in Indonesia with other countries

Productivity problem	Indonesia rank	Nigeria rank	UK rank	USA rank
Lack of material	1st	1st	1st	1st
Lack of tools	5th	3rd	5th	2nd
Interference	3rd	6th	2nd	5th
Absenteeism	4th	5th	6th	6th
Supervision delays	6th	4th	4th	4th

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Rework	2nd	2nd	3rd	3rd

The diversity of methodologies of quantification or evaluation of the factors makes it difficult to compare findings. According to a study carried out in seven countries by (Thomas, 1991), material delay due to poor procurement procedures and stochastic nature of lead-times, size and organization of material storage area, material handling, distribution and availability, tools and equipment availability are some of the factors that were considered significant in disrupting production.

Guhathakurta et al (1993) found that there is a 100 percent agreement on the four most delay causing factors between the US and Nigeria. The factors affecting productivity were identified as lack of materials, lack of proper tools, repeat work, and inspection delays. These four factors were further narrowed down as shown in table 2 below.

Table 2.2: Factors affecting productivity

Main reason	**Causes**
Lack of materials	• Lack of transporting equipment • Unavailability of transporting equipment • few laborers to retrieve orders from the warehouse • Excessive paperwork for requesting material • Nonexistence of certain vital items in the company

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

	• Receiving of improper materials • Lack of proper planning by supervisors • Cash flow problems
Lack of proper tools	• Cash flow problems • Improper maintenance • Poor quality tools • Insufficient tools
Repeat work	• Poor quality of engineering drawings • Poor inspection techniques • Poor analysis of control charts
Inspection delays	• Difficulty in the recruitment of supervisors • Difficulty in the recruitment of workers • A high rate of labor turn over • Absenteeism • Communication problems with foreign workers

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

On the other hand, factors affecting labor productivity in Tanzanian building construction were studied. The investigation demonstrated that Key factors affecting productivity were financial incentives, non-financial incentives, level of skills of the workers, level of mechanization and quality of leadership (Lema, 1995).

Anderson (1996) reported that the common reasons for low productivity in the manufacturing industry could be attributed to a supervisor supervising too many workers simultaneously, workers doing very heavy work due to lack of automation, waiting for material, waiting for tools, machine breakdowns, poor facility layout, working gangs out of balance among others.

Enchassi et al (2000) studied the relationship between the effectiveness of production manager style of leadership and workforce productivity in Palestine and United State of America. The results of this study showed that there is a significant positive relation between the effectiveness of production managers and the level of workforce productivity.

It was mentioned by Teicholz (2001) that possible causes of declining of labor productivity in US construction sector from 1970 to 1998 include inadequate training, fewer young worker entering the construction industry, increased complexity of the projects, more safety procedures and greater time pressure on project completion.

Thomas et al (1991) studied the effect of workforce management quality on labor productivity. The results of study indicated that inefficient workforce management accounts for an average of almost 65% of the total inefficient work hours in these projects. The workforce errors observed in these projects were overstaffing, interference with other crews and no alternative work assigned.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Rojas et al (2003) studied many factors, which affects labor productivity in the manufacturing sector in United State of America. The results of study indicated that management systems, strategies, and manpower issues were the two areas with greatest potential to affect labor productivity. The Important management systems and strategies issues were management skills, material and equipment management and work scheduling. On the other hand, the important manpower issues were training and education, employee motivation, and labor experience.

2.3Summary of the chapter

It is clear from the above that factors affecting productivity are both numerous and diverse. It is nevertheless not exhaustive. It is not possible to quantify the effect of each on productivity in a predictable manner since what may be significant in one environment, may be insignificant in another situation. Nevertheless, the literature provides a pool of factors that may be considered for productivity studies at Del Monte Kenya Limited. The following is a summary of factors that have been identified in literature: lack of some materials in the Kenyan market, worker absenteeism, poor facility layout leading to congestions, lack of motivation by workers, lack of some tools, delays in material delivery, unskilled labors, mechanistic Organizational structures, poor Management skills, disruption of power and water supply, rework, supervisors absenteeism, safety considerations, the age of laborers, job size, job complexity, poor material and equipment management, poor work scheduling, labor experience, employee motivation and training and education. All the above variables can be categorized as Machines, Men, Methods, Materials and Measurements.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

2.4 Conceptual framework

This shows the relationship between the independent and the dependent variables. The dependent variable is productivity. The framework shows how the independent variables which can be categorized as Machines, Materials, Methods, Men and Measurements influences productivity.

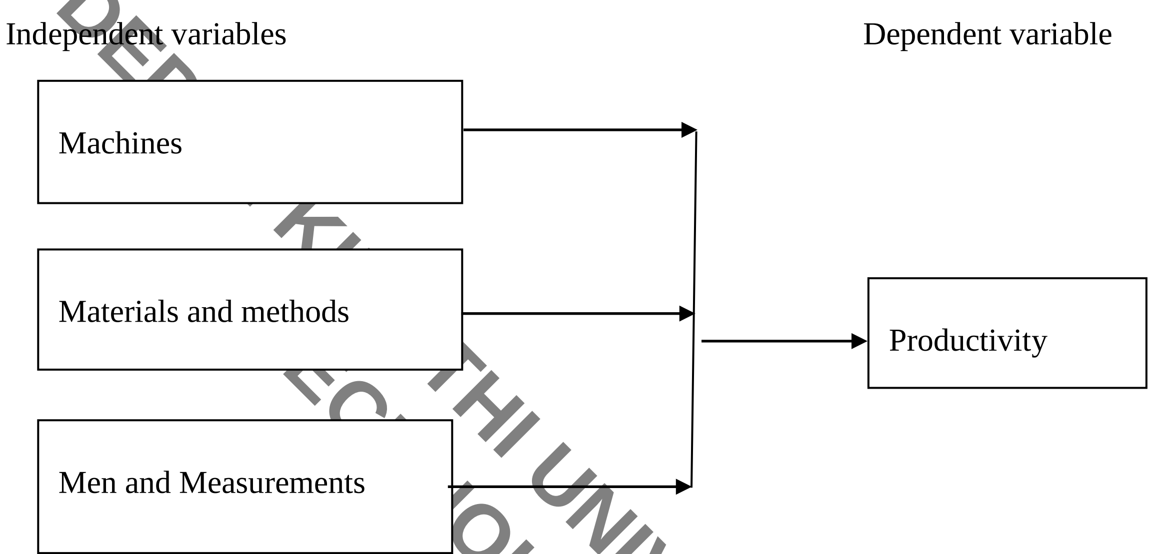


Figure 2.2: Conceptual framework.

CHAPTER THREE

3.0 Research Design andMethodology

3.1 Introduction

This chapter dealt with the selection and justification of the research design, sampling strategy, data collection methods and methods for data analysis.

3.2 Research design

The case study of Del monte Kenya (DMKL) was used in this research to represent manufacturing industries in Kenya since it is involved in production process. In this study both exploratory and descriptive methods were adopted. Exploratory research method was used to generate aposteriori hypotheses by examining a data-set and looking for potential relations between variables. In the recommendations stage, a grounded theory research was employed. A grounded theory research is a systematic research process that works to develop a process, and action or an interaction about a substantive topic (Adèr, 2008). On the other hand, a descrptive research method was taken up to investigate the factors that affect the productiviity at DMKL processing plant. This is in line with Best and Khan (1992) who asserts that a descrptive reaserch seeks to establish factors affecting a certain outcome. Case study enabled the researcher to study the area selected entity in depth in order to gain insight into the larger cases.Secondly to desccribe and explain rather than predict a phenomenon.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

In order to evaluate the relationships between factors that affect productivity, a regration analysis and correlation matrix was used and obtained using Gen Stat to show the relationship between equipment availability/performance and productivity. This was presented in mathemetical model that shows their signifigant trelationships while tables were used to show the correlation matrix.Using root-cause analysis (RCA) through Pareto charts, 5 'WHYS' and Ishikawa diagram (fishbone), possible causes for each problem were tested and the root causes finally determined. Root cause analysis is a method used to denote a class of problem solving methods aimed at identifying the root causes of a problem or event. Its practice is predicted on the belief that problems are best solved by attempting to correct or eliminate root causes as opposed to merely addressing the immediate obvious symptoms.

3.3 Sampling strategy, data collection and analysis

The study targetedDMKL processing plant comprising of labeling and packing section. The target population of the labeling section is the six labeling lines. Out of the six lines three lines will be selected randomly in each section for data collection. This ensured that all elements within the population are given an equal chance of being selected thus reducing bias. Weekly data recording on machine availability, performance and quality for the last three years was obtained from the data store. Out of the obtained data, three days that had full operation in every week was purposefully selected and averages for the three days calculated for each given variable. The weekly averages were then recorded and subjected to a regression analysis to determine the influence of various factors on the productivity in the processing plant. Apart from the secondary data that was obtained from the archives, primary data was also used by following an operation for a period of three months so as to justify the secondary data that was used for the study. Document research was also used in this study. This is a research method that involved the study of existing documents such as reports, articles, conference papers and journal papers on productivity improvement. Content analysis was used to analyze this particular data. Descriptive statistics such as tables, charts, and percentages frequencies was used for data presentation through the help of Microsoft Excel and Gen stat. In the packing section, interviews with workers, observations and secondary data will be used.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

3.4 Determination of factors affecting productivity

3.4.1 Determination of the impact of equipment performance and availability on productivity

Data on all the operation days for the last twelve months was obtained. The data sheet showed the daily records on the time each operation shift begins, the down time due to power failure, breakages, material shortages and maintenance are all recorded and the time taken for each equipment to determine its availability. Apart from the secondary data that was obtained from the archives, primary data was also used by following an operation for a period of one week so as to justify the secondary data that will be used for the study.

For equipment performance, the rated capacity per unit time for the equipment will be recorded from the manufacturers' manual. Time spent to achieve every output will be recorded. The performance of the equipment will then be achieved by comparing the production per unit time to the rated capacity.

3.4.2 Investigation of the effect of materials (inventory) on productivity.

The research design that was employed to achieve this objective was a descriptive case study, generally quantitative in nature.Data on total inventory was obtained andComparison to how inventory correlates with production cost was sought out in order to show its total effect on productivity.

3.5 Determination of the root causes of low productivity

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Having identified the major causes of low productivity in DMKL, this objective sought to identify the root causes of these factors by collecting data on the various variables under the factors. For instance under machines, secondary data on machine availability and performance was obtained and the causes of the unavailability andinefficiency recorded. Similarly data on the causal factors of excess inventory was obtained and recorded. Using root-cause analysis (RCA) through Pareto charts, 5 'WHYS' and Ishikawa diagram (fishbone), possible causes for each problem were tested and the root causes finally determined. Root cause analysis is a method used to denote a class of problem solving methods aimed at identifying the root causes of a problem or event. Its practice is predicted on the belief that problems are best solved by attempting to correct or eliminate root causes as opposed to merely addressing the immediate obvious symptoms.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

3.6 Determination of strategies for productivity improvement

The research design that was employed to achieve this objective was through decision tree analysis, a process that first involved the study of existing documents whichincluded books, articles, conference papers and journal papers. The main focus was to highlight the similarities and different strategies to improve productivity. These documents were corded against categories, leading to conclusions about common themes of the objective. Data on the background and historical context was gathered and reviewed so that knowledge of history and surrounding in the specific sections comes in part from reviewing documents. Decision tree analysis was used to summarize and categorize data aroundaccording to different strategies that are used to improve productivity. These matrices provided an overview and enabled comparisons to be easily doneto the key issues. After formulation of possible solutions through documentary review, the solutions were evaluated using decision tree analysis and best solution chosen.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

CHAPTER FOUR

4.0 Results and discussion

Introduction

In this chapter, the researcher analyzed both qualitative and quantitative data. The percentage methods of data analysis was used to compare the ideal situation and theoretical concepts with the current real scenario to generate conclusions as Pareto charts and tables were used to show trends of the analysis and findings.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

4.1 Determination of factors affecting productivity

4.1.1 Determination of the impact of equipment performance and availability on productivity

Equipment availability is the ratio of operating time to planned time while performance is the ratio of the output to the product of operating time and the rated capacity. The effect of equipment performance and availability on productivity varied substantially. A 6% negative change in equipment availability causes a negative change of 33% in productivity whereas the same change in productivity is caused by a negative change of 14% in equipment performance in the first month. In February, a positive change of 9% in equipment availability together with a 31% positive change in the performance of the equipment improves productivity by 40%.

Table 4.1: Variation of availability and performance with productivity in the labeling section

Month	Availability	Performance	Productivity(cases per man hour)	target	Change in availability	Change in performance	Change in productivity
Jan	85	49	8.27	15	100%		
Feb	80	42	5.54	15	-6%	-14%	-33%
Marc	87	55	7.73	15	9%	31%	40%
April	85	56	8.1	15	-2%	2%	5%
May	87	58	8.7	15	2%	4%	7%
June	80	60	9.3	15	-8%	3%	7%
July	92	65	12.64	15	15%	8%	36%
Aug	91	60	10.23	15	-1%	-8%	-19%
Sept	82	44	6.66	15	-10%	-27%	-35%
Oct	83	47	8.11	15	1%	7%	22%
Nov	85	52	9.63	15	2%	11%	19%
Dec	81	42	6.37	15	-5%	-19%	-34%

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Similar trend is seen though the months, however it is important to note that a slight change in the availability and performance of the equipment impacts a measurably larger change in the productivity. At the labeling section, the correlation analysis between availability and performance of equipment with productivity showed different strengths. Equipment performance is strongly related to Productivity with a correlation of 87% while the correlation between availability and productivity is 77%. The correlation between availability and performance is also significant p= 0.008 with a correlation of 72.3% and therefore cannot be overlooked in the model. A regression analysis between equipment availability and productivity showed that about 88.8% (r^2=0.88) of the total variation in the productivity can be explained by equipment performance and availability.

The model fit for the labeling section was of the form

Y= Ma + Nb+c

Y= 1.29a+ 0.99b + 0.018; where

Y= Productivity

M& N= Numerical values

a= Performance

b = Availability

C= A constant

Therefore the model takes a general form of the equation:

Productivity = 1.29Performance +0.99 Availability +0.018

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Table 4.2: Variation of availability and performance with productivity in the cannery section

Month	Availability	Performance	Productivity(tons per plant hour)	Target	Change in availability	Change in performance	change in productivity
Jan	80	77	51.36	66.67			
Feb	79	75.5	48.97	66.67	-1%	-2%	-5%
Marc	82	80	56.54	66.67	4%	6%	15%
April	82	81	57.52	66.67	0%	1%	2%
May	81	81	58.22	66.67	-1%	0%	1%
June	81	80.4	57.94	66.67	0%	-1%	0%
July	82	80	56.72	66.67	1%	0%	-2%
Aug	80	78	53.87	66.67	-2%	-3%	-5%
Sept	82	81	58.44	66.67	2%	4%	8%
Oct	81	80	56.76	66.67	-1%	-1%	-3%
Nov	81.2	81	58.53	66.67	0%	1%	3%

Dec	81	82	61.25	66.67	0%	1%	5%

At the cannery section, the results were similar to those at the labelling section. All the parameter estimates were significant in the model. All the variables perfomance and availability of the equipment can be included to the model to improve the precision with which productivity can be improved.the variance accounted for by the model is 97.1% with r^2 =0.97. The model fit is:

Productivity = 2.70Performance +0.41 Availability +0.002

Therefore the model takes a general form of the equation:

Y= Ma + Nb+c

Y= 2.7a+ 0.4b+ 0.002; where

Y= Productivity

M& N= Numerical value

a= Performance

b = Availability

C= A constant

This implies that when all other factors affecting productivity are held constant, unit increase in equipment availability results to a 0.4 increase in productivity while a unit increase in equipment performance results in a 2.7 units increase in t productivity.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Table 4.3: Correlation and Regression analysis

Equipment factor	r^2	Regression line	P value
Availability(Labeling)	60.8	PR= 3.02 Availability+ 0.019	0.003
Performance (Labeling)	86.4	PR= 1.62 Performance + 0.03	<0.001
Availability(Cannery)	70.7	PR= 2.89 Availability+ 0.14	0.006
Performance(Cannery)	97.1	PR=2.39Performance + 0.003	<0.001

PR- Productivty

In order to evaluate the relationships factors that affect productivity, a correlation matrix was obtained using Gen Stat. The table below shows the correlation matrix. The Guilford 5- level interprative model was employed in interprating the coefficients; r<0.2= marginal correlation correlation, r=0.2-0.4 low correlation,r=0.4-0.7= moderat correllation, r = 0.7- 0.9 = high correlation and r=>0,9 extremely high correlation. The correlation matrix showed that availability and performance of equipment in the labelling section are highly correlated to productivity(r = 0.77;p-value< 0.001 and r = 0.87;p-value0.002 respectively (Table 6))

Table 4.4: Correlation Matrix

Productivity	Productivity	Availbility (Labelling)	Performance (Labelling)	Availbility (Cannery)	Performance (Cannery)
Productivity	1				
Availbility(L)	0.77	1			

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Performance (L)	0.87	0.75	1		
Availbility(C)	0.74			1	
Performance (C)	0.98			0.80	1

In the cannery section, similar correlation to that in the labeling section was seen where by availability of equpment was highly correlated to productivity (r = 0.74) whereas the results revealed that equpment performance is extremelycorrelated to productivity (r= 0.98). In both sections the correlation between equipment availability and performance cannot be overlooked since the results indicated an equally high correlation of r =0.73 in the labelling and r = 0.80 in the cannery section with a p value of < 0.001.

From the results above, it indicates that equipment availability and performance in both the cannery and labelling section have positive significant relationship with productivity (p value < 0.05). There was a postive relationship (r=0.77, P-value <0.05) between productivity and availabiity in labelling section while in cannery section, similar results were witnessed with (r=0.74, P-value <0.05). The relationship between performance and productivity also showed postive relationship in labelling section (r=0.87, p-value <0.05) while in cannery section, similar postive relationship (r=0.98, p-value <0.05) was oberved. The results indicate that improving equipment performance and availability improves productivity on a great length.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

4.1.2 To what extend do materials (inventory) affect productivity?

The change in inventory has a substantial change on total production cost, a slight increase in inventory resulted in increase in production cost while a decrease in inventory resulted in a decrease in production cost. Based on the results, inventory had a significant positive relationship with production cost hence negative relationship with productivity since productivity is the ratio between output and input. The table shows the size of inventory in cases and how it affects production cost and productivity in general.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Table 4.5 relationship between inventory and production cost

		Production Cost/case(Ksh)		
2012	Inventory (Cases)	Actual	Target	% variation
January	462,634	1130	1147	-1%
February	459,730	1140	1147	-1%
March	768,558	1160	1147	1%
April	788,295	1160	1147	1%
May	712,198	1150	1147	0%
June	765,300	1250	1147	9%
July	950,482	1420	1147	24%
August	901,540	1410	1147	23%
September	840,042	1300	1147	13%
October	908,782	1400	1147	22%
November	1,059,821	1470	1147	28%

December	1,268,006	1500	1147	31%

From table4.5, it is noted that as the year began the inventory was lower and kept increased as the year progressed. The increase in inventory is directly proportional to the total cost of production. This in turn leads to a decrease in productivity which is inversely proportional to production cost. From the table above the actual cost of production per case is estimated and set at Kenya shillings 1147. At this set production cost, the company will ensure a favorable profit margin. As the inventory increases the cost of production per case increases thus eating in to the profit margin that has been set. From the correlation analysis, it is evident that that inventory has a strong correlation r = 0.882 with the cost per case with a value of$P < 0.01$. Due to this foregoing situation the company may start incurring losses since they cannot just increase the product price due to an increase in the cost of production. High inventory levels have been known to slow down production or lead to a shut down for a while so as to allow for management and control of finished products.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Table 4.6 Matrix showing correlation between inventory and cost per case

Variable	Inventory	Cost per case
Inventory (cases)	1	0.882
Cost per case	0.882	1

$P<0.001$

4.2 Determination of the root causes of low productivity

4.2.1 Root causes of equipment unavailability and performance

Several factors were identified through secondary data to be the causes of equipment unavailability in labeling section; these factors included breakdowns, power failures, set up, minor stoppages and lack of materials as illustrated in fig 4.6

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

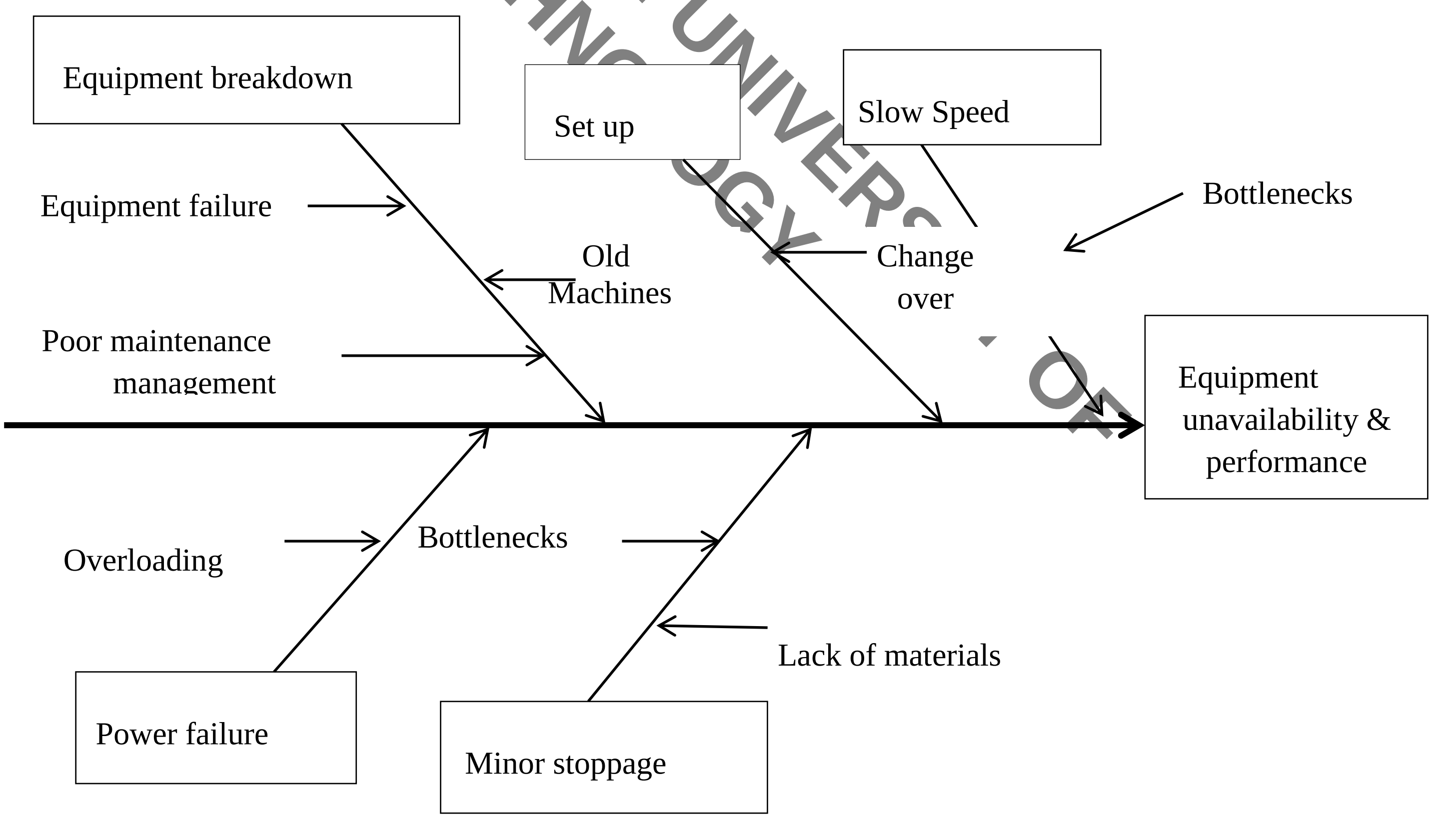


Fig 4.1: Cause and effect diagram in labeling section

Based onPareto analysis,equipment breakdown contributed to 50% of the equipment unavailability while power failures contributed to 30%. Setups, minor stoppages and material contributed to 20% of equipment unavailability. Through Pareto analysis,Equipment breakdowns and power failure were found to be the vital few and root causes of equipment unavailability in labeling section since they contributed to 80% of equipment unavailability.

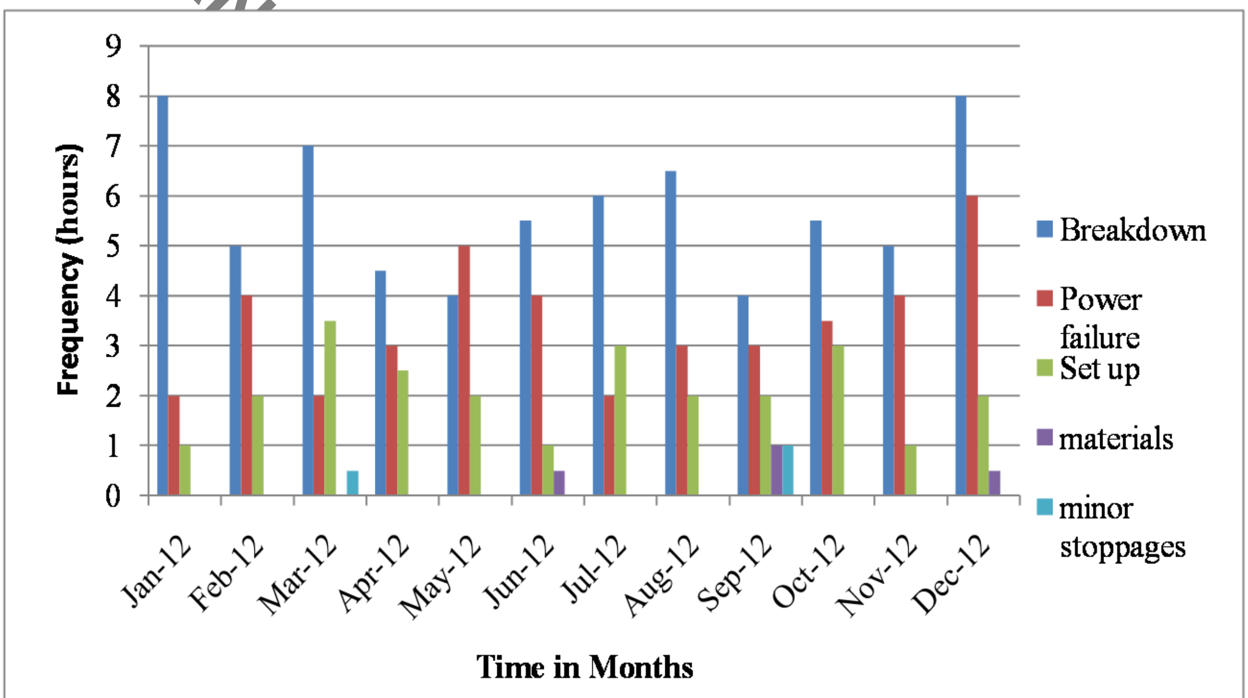


Fig 4.2: Frequency of down time and causal factors in labeling section

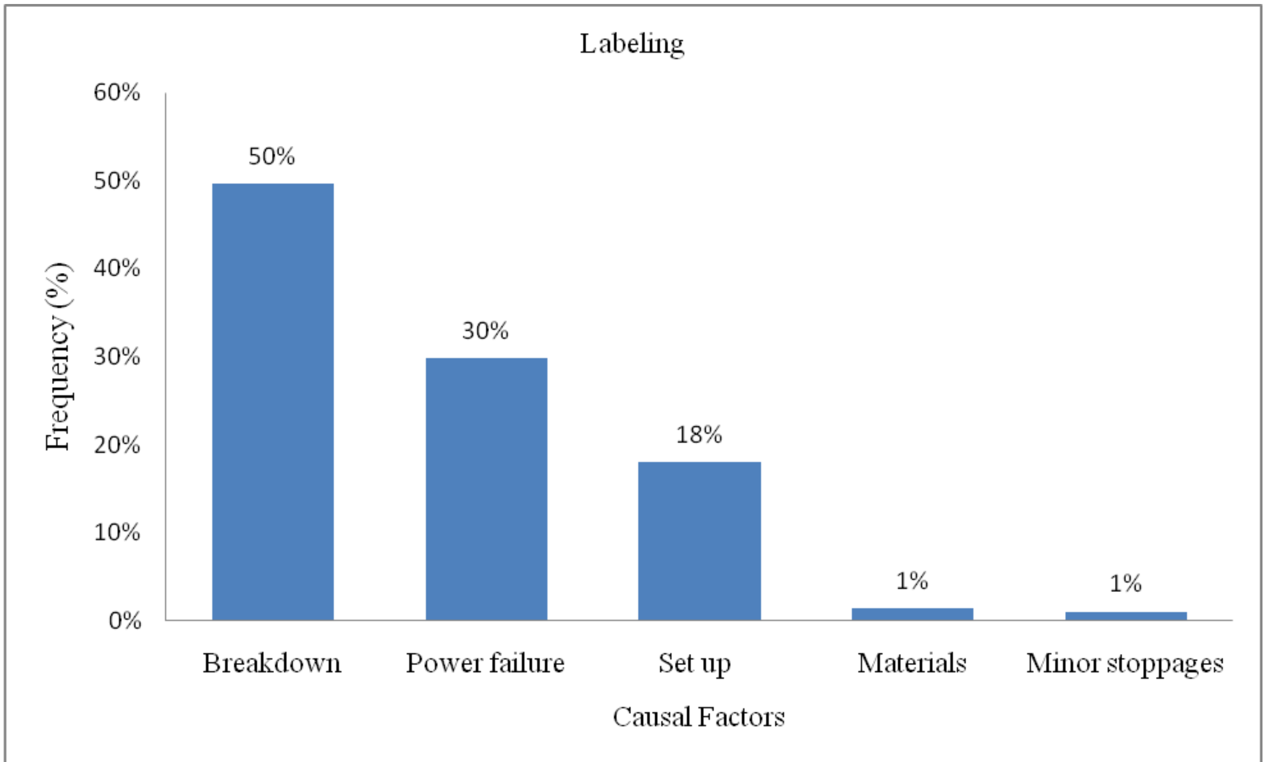


Fig 4.3: Pareto chart on frequency of down time and causal factors in labeling section

In cannery section,several factors were identified as causes of equipment unavailability; these factors included boiler failure,power factors, breakdowns, setup, and minor stoppages as illustrated in fig 4.3

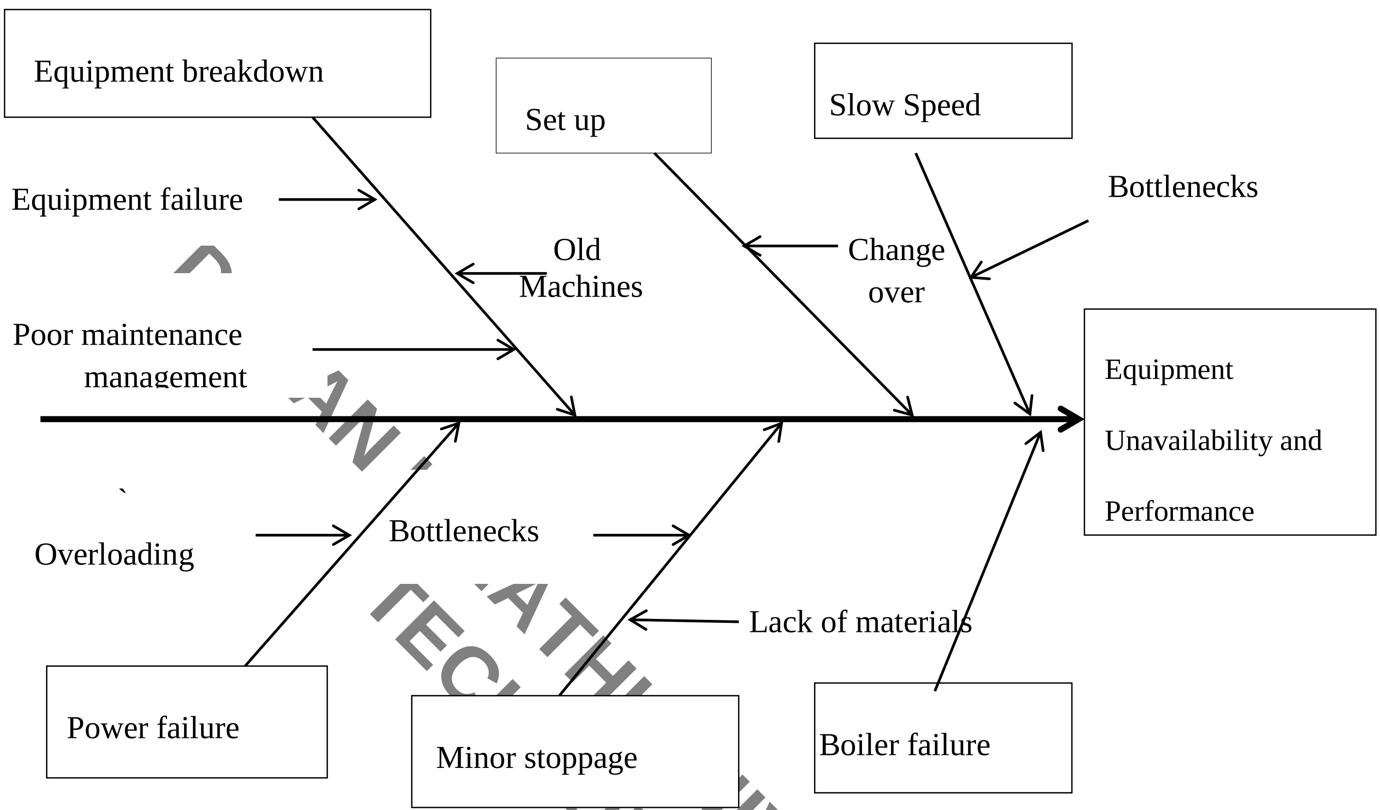


Figure 4.4: Cause and effect Diagram in cannery section

Based on Pareto analysis, breakdowns contributed to 59% of equipment unavailability while power failure contributed to 38%. Setups and minor stoppages contributed to 3% of equipment unavailability. Through Pareto analysis, breakdownsand power failures were cited as the vital few and root cause of the problem of equipment unavailability in cannery section.

Two causes of poor performance were identified in both cannery and labeling section, these included minor stoppages and reduced speed. In both cannery and labeling sections, minor stoppage was identified as a less contributor to equipment poor performance. Itcontributed to poor performance by 1% respectively leaving only one cause ofreduced speed as probable root cause of the problem of poor performance.

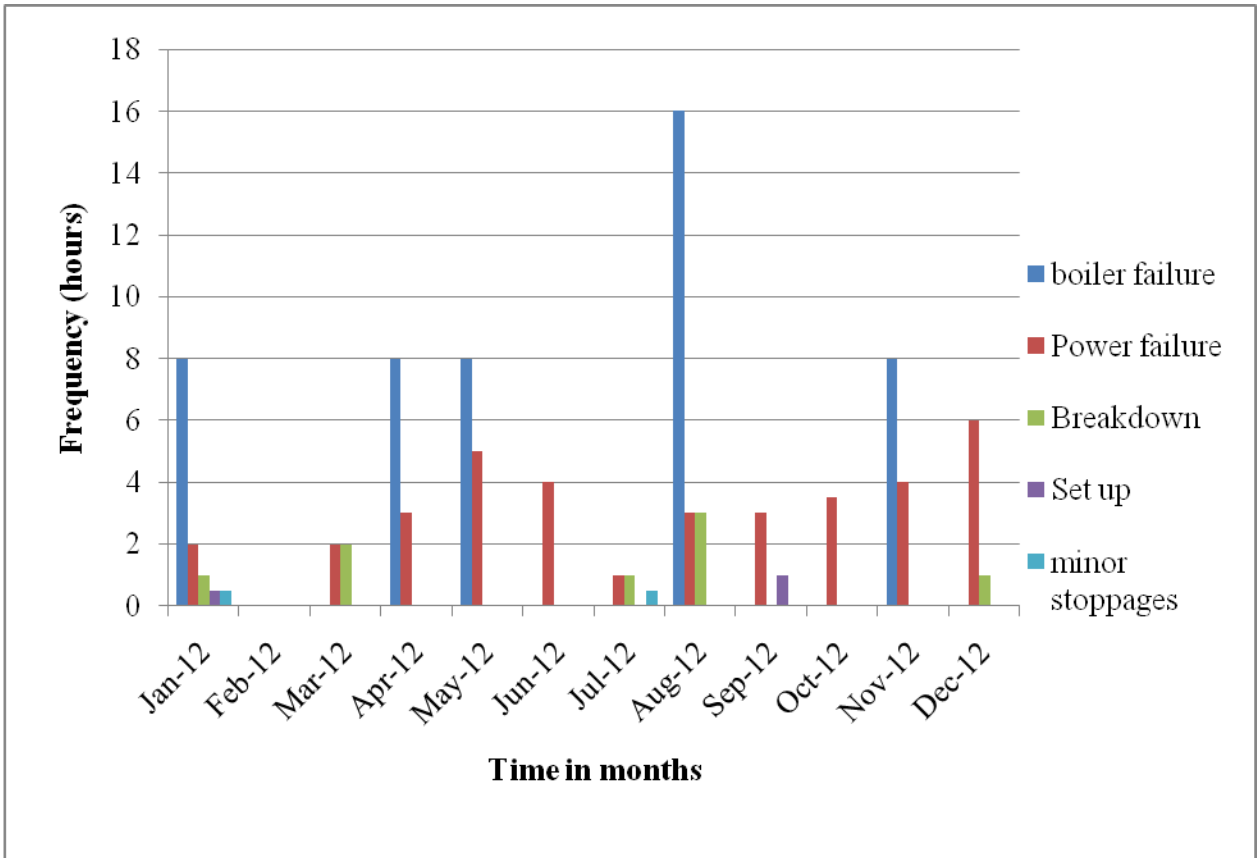


Figure 4.5: Frequency of monthly down time and causal factors in cannery section

SITY OF

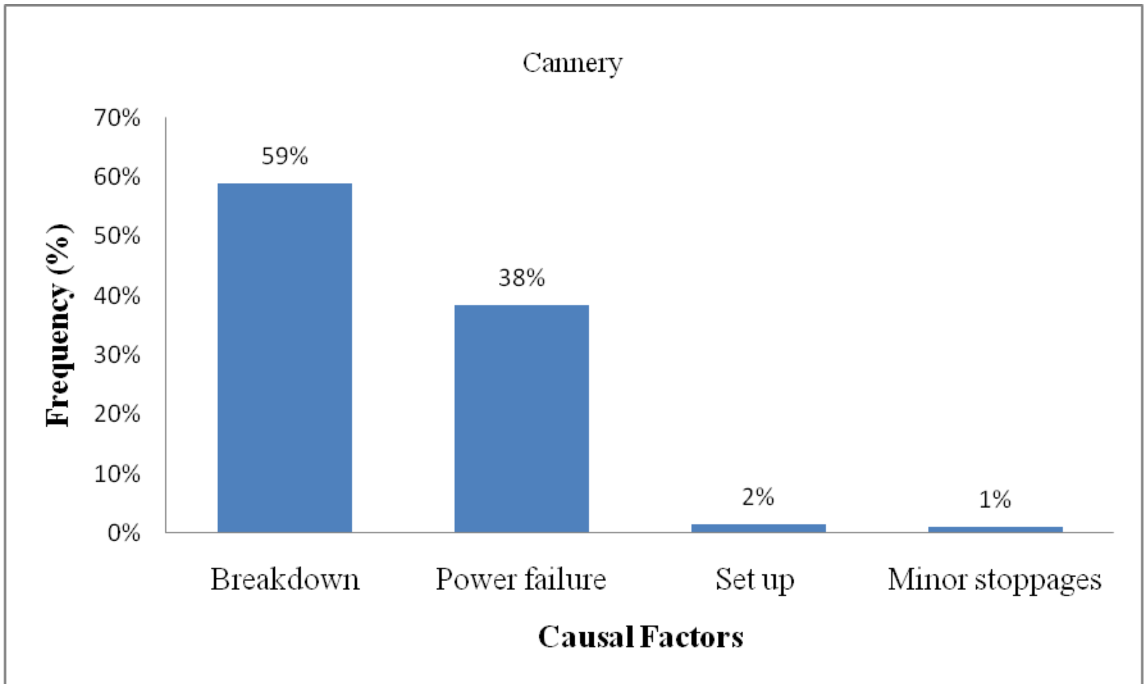


Figure 4.6: Pareto chart showing frequency and causal factors in cannery section

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

4.2.2 Root causes of huge inventory

Two major factors were identified as causing increased inventory in DMKL plant;these factors include low sales and over production.

In order to fully investigate the root cause of increased inventory, the research employed the '5 Whys' method as the simplest technique for structured root causes analysis. This is a question asking method used to explore the cause/effect relationships underlying the problem. The research kept on asking the question 'why' until meaningful conclusion were reached.

5 WHY'

a) Why increased inventory?
   - Because of low sales

b) Why low sales?

- Un-competitiveness in product price

c) Why not compete in product price?

- Product price higher than our competitors

d) Why is the product price high?

- High production cost

e) Why high production cost?

- Increased wastes

Based on the analysis above, the root cause of increased inventory is the high production cost due to high wastes in the plant.

4.3 Determination of strategies for productivity improvement

4.3.1 Strategy formulation

The strategy(s) to be used to improve productivity in manufacturing industries will be the optimal solution that addresses the root causes of low productivity. Based on the root cause analysis discussed earlier in this research, equipment unavailability and poor performance which negatively affects productivity are caused by equipment breakdowns, power failures and reduced speed due to ineffiiency and bottlenecks in the production system. The results indicated that improving equipment performance and availability by reducing breakdowns and bottlenecks improves productivity on a great length.The root cause of excess inventory which directly affects productivity was identified as high production cost due to many production wastes.Several strategies were formulated as possible solutions to the problem of low productivity in DMKL processing plant.These solutions included benchmarking, TPM technique, Lean Sigma, Bio-mas plant and

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Theory of Constraints (TOC).Table 4.7 summarizes the underlying problem with its causes and appropriate proactiveoptimal solution that fully addresses the problem

Table 4.7: Underlying problem with its causes and appropriate proactive solutions

Core problem	**Causes**	**Root causes**	**Effects**	**Viable solutions**
Low productivity	Equipment unavailability	Breakdowns	Unachieved customer/production demand	-TPM -Bench marking
	Equipment poor performance	-Reduced speed -Power failure -Bottlenecks	Unachieved customer/production demand	-TPM -Theory of constraints (TOC) -Bio-mas plant
	Excess inventory	High production cost	Losses	-Lean system -Six sigma

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

4.3.2 Evaluation of strategies

Decision tree analysis was used to evaluate the strategies/solutions in order to choose the best solution that will solve the root causes of the problem of low productivity.

Based on the above results, it is clear that various strategies and techniques can be used to improve productivity. However, each strategy has its strength and weakness and best applicable to specific problem. According to the results, Total Productivity maintenance (TPM) is the best strategy to solve problems of equipment breakdowns which affects productivity at a great length. Lean manufacturing system was identified as the best strategy/solution in solving the problem of high production cost which affects productivity. Power failure problems can only be solved by in investing in a power plant i.e. Bio-gas or Gen sets depending on the size and capacity of the plant in relation to cost and its benefits. Benchmarking can also not be overlooked although it does not solve specific problem but it can be used as a general strategy.

From the above results, the best strategy for excess inventory is the implementation of Lean manufacturing system. Consequently the best strategy for solving the problem of poor performance and equipment unavailability is the implementation of TPM strategy and installation of Bio-mas plant. The evaluation of strategies is illustrated using decision tree analysis in fig 4.7and fig 4.8.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

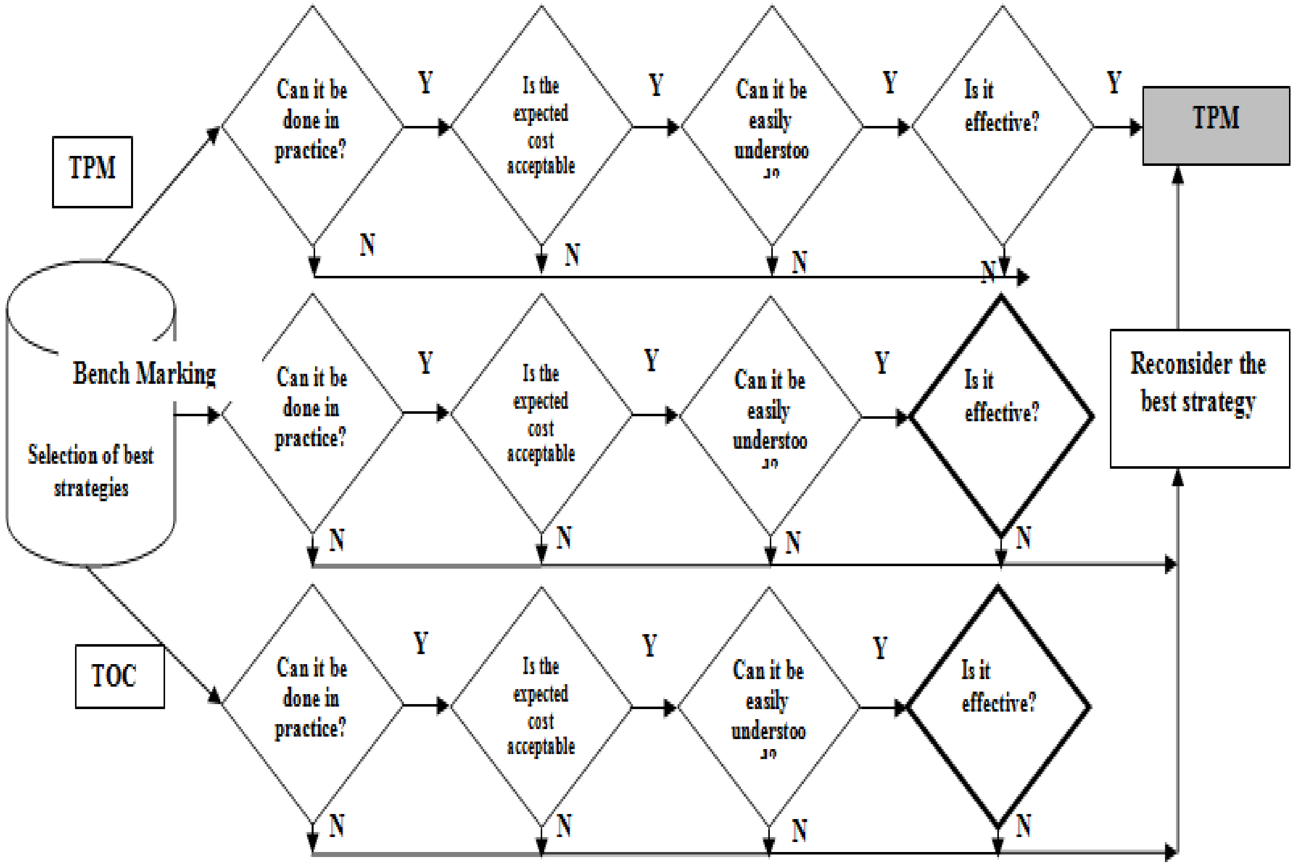


Figure 4.7: Decision tree analysis in evaluating strategies

ERSITY OF
OGY

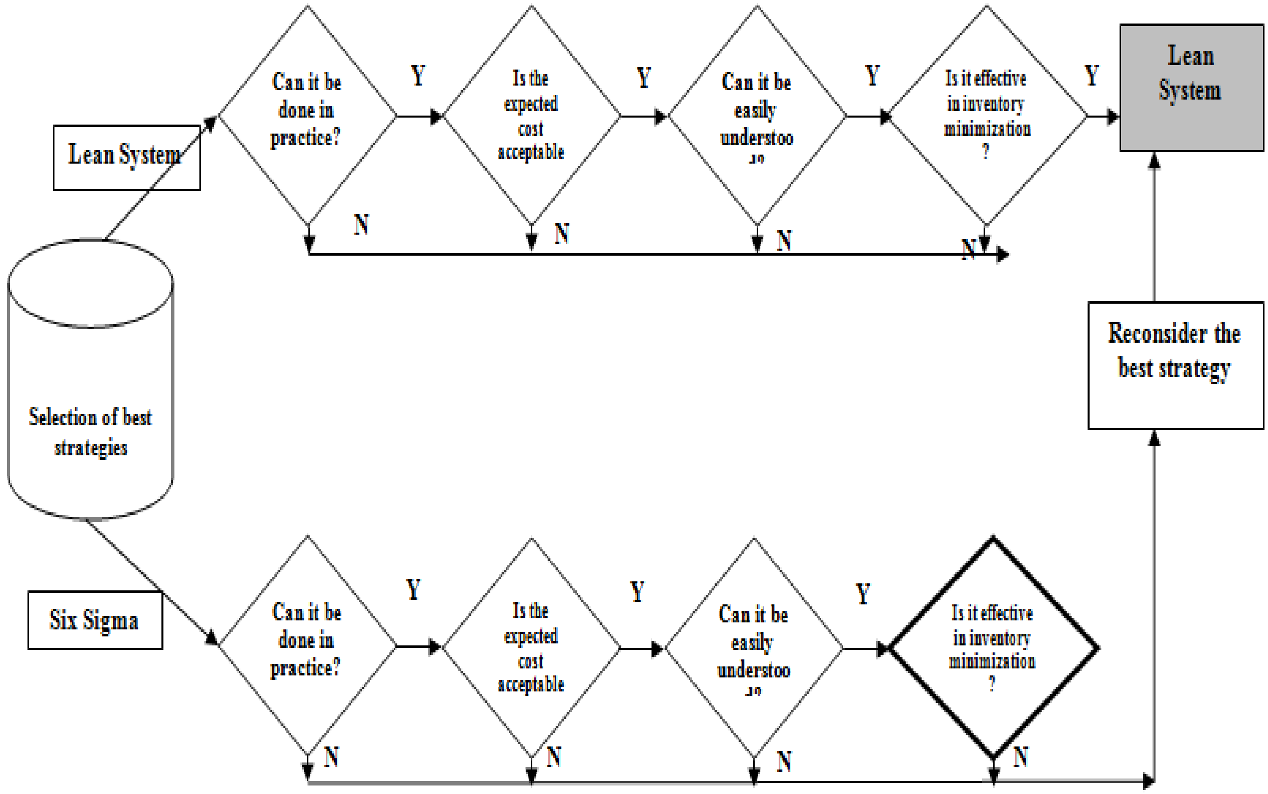


Figure 4.8: Decision tree analysis in evaluating strategies

UNIVERSITY OF ... OLOGY

4.3.3 Strategy implementation

The optimal strategies need to be implemented systematically with the consideration of the overall objective of the organization. It involves all operations and work centers including suppliers, people, equipment, materials, procedures and customers. This is demonstrated using Deming's PDCA model of Plan-Do-Check-Act. This involves identifying the improvement strategies (TPM and Lean manufacturing) and making a plan before testing and checking if the plan works before finally implementing the plan. It also involves formulating standard operating procedures (S.O.P) to hold the gains.

4.3.4 Deduction

Equipment availability, performance and inventory have positive significant relationship with productivity. The problem of low productivity is caused by equipment unavailability, poor performance and excess inventory. The root causes of equipment unavailability and poor performance were identified to be equipment breakdowns, power failures and reduced speed due to inefficiency and bottlenecks in the production system respectively. The results indicated that improving equipment performance and availability by reducing breakdowns and bottlenecks improves productivity on a great length. Inventory was also found to be the greatest hindrance to productivity, the root cause of excess inventory which directly affects productivity was identified as high production cost due to many production wastes.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

CHAPTER FIVE

5.0 Conclusion and recommendations

This chapter entirely summarizes all the findings that the researcher analyzed, it also constitute of the researchers conclusion and final recommendations on what should be done to improve productivity in manufacturing industries based on the result from this case study.

5.1 Review of research objectives

5.1.1Determination of the impact of equipment performance and availability on productivity

Productivity is considered the main value adding strategy within the manufacturing sector.Factors such as equipment availability and performance are crucial to improvement of productivity. It is evident that improving the equipment performance of equipment will improve productivity by significant margin. Similarly, availability of equipment is vital for productivity improvement. However it was also found out that productivity and availability are highly related therefore for successful improvement of productivity, machines must be made available. Therefore equipment availability and performance significantly affect productivity in Del Monte Kenya and likewise in similar companies.Equipment breakdowns and power failure were found to be the root causes of equipment unavailability. Reduced equipment speed due to bottlenecks and inefficiency was found to be the root cause of equipment poor performance.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

5.1.2 Investigation of the effect of materials (Inventory) on productivity

Wastes significantly pull down productivity as seen in this study. Eliminating these wastes can improve productivity by a very big margin. This can be achieved in the sense that when inventory is high, the cost of production becomes very high due to holding costs. The root cause of increased inventory was identified as high production cost due to many production wastes. It is therefore advisable that company to rather lower the production cost through embracing and implementation of lean manufacturing system which reduces wastes and production cost. This will allow the product to be competitive in the market through low prices hence high sales that will reduce inventory at a high rate which subsequently minimizes the cost of stock take, security and warehouse expenses.

5.1.3 Determination of the root causes of low productivity

The researcher's goal of establishing the root cause of low productivity was well achieved. Equipment breakdowns and power failure were found to be the root causes of equipment unavailability which affects productivity in manufacturing industries. Reduced equipment speed due to bottlenecks and inefficiency was found to be the root cause of equipment poor performance which also affects productivity. The root cause of increased inventory which directly affects productivity was identified as high production cost due to many production wastes.

5.1.4Determination of strategies for productivity improvement

The research wanted to achieve the best strategies to be employed to improve productivity in manufacturing industries in Kenya. It is clear based on the results that various strategies and techniques can be used to improve productivity. However, each strategy has its strength and weakness and best applicable to specific problem. TPM and

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Lean manufacturing system is the key to productivity improvement although and other strategies like benchmarking cannot be overlooked.

5.2 Key Findings

The research found out that equipment availability and performance have positive significant relationship with productivity.The problem of low productivity is caused by equipment unavailability and poor performance. The root causes of equipment unavailability and poor performance were identified to be equipment breakdowns, power failures and reduced speed due to inefficiency and bottlenecks in the production system respectively. The results indicate that improving equipment performance and availability by reducing breakdowns and bottlenecks improves productivity on a great length. This is also in line with Thomas (1991) who concluded that management issues including equipment availability affects productivity.

Inventory was also found to be the greatest hindrance to productivity. The root cause of increased inventory which directly affects productivity was identified as high production cost due to many production wastes. When there is too many goods produced and stored, this increases the cost of production due to high holding costs, this influences the product price making the product uncompetitive with other competitors. These results conquer with Shigo (1989) findings that production waste significantly affects productivity.

5.3 Conclusion

From this research, it can be concluded that equipment availability and performance significantly affects productivity. Similarly inventory was found as a major factor

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

hindering productivity. It can also be concluded that the root causes of low productivity includes equipment breakdown, reduced equipment speed and high production cost due to increased production waste. Therefore applying and implementing TPM and Lean manufacturing System as strategies reduces equipment breakdowns, bottlenecks and reduces production cost which significantly improves productivity.

5.4 Research implication

The findings of the study concurred to other studies and therefore it applies across the board. In practice, the research depicts the real situation in manufacturing industries hence the findings are general in nature and can be applied in all manufacturing industries.

5.5 Research contribution

From this study, the use decision tree system of strategy evaluation was successfully used to determine the best strategy for productivity improvement. This system can be adopted by both manufacturing and non-manufacturing industries to help in decision making systematically in identifying the best solution to a specific problem.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

5.6 Recommendations

The researcher recommends that to curb the problem of low productivity in DMKL plant caused by equipment unavailability and poor performance, there is an urgent need to Implement Total Productive Maintenance (TPM) in totality. This philosophy need to have a total participation of all levels in the organization in addition to maximizing equipment effectiveness and establishing a thorough system of preventive maintenance.

Consequently, to solve the problem of power failures, it is recommended that investing in a cost effective green energy power plant like Bio-mas plant would significantly address the problem. The implementation of Lean manufacturing system has also been recommended to solve the problem of low productivity due to high production cost.This system will ensure elimination of all wastes which will improve operation efficiency and hence increased sales due to lower prices which finally reduces inventory to an economic level.

5.7Suggestion for further research

Analysis in the study showed a very high correlation between availability and performance therefore further studies should be carried out to establish how the two are related and how they jointly affect productivity. More research needs to be conducted on implementation, testing and evaluation of lean manufacturing system and Total productive maintenance in manufacturing industries.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

References

Adams, C. W., Gupta, P., & Wilson, C. E. (2003). *Six Sigma Deployment.* Burlington, MA: Butterworth-Heinemann.

Andersson C. A., M. D. (1996). *Site management handbook.*

Armstrong, M. (1988). *Handbook of human resource management.* Kogan Page Ltd.

Dangayach, G. &Deshmukh, S. (2001). Manufacturing strategy: literature review and some issues. International journal operations & production management, 21(7), pp.884-932.

Enchassi A., a. L. (2000). Comparison between the leadership style of American and Palestinian Construction managers. *Islamic University Journal*, 1-33.

Fleischer J., U. (2006). Calculation and Optimisation Model for Costs and Effects of Availability Relevant Service Elements. *Proceedings of LCE2006*, (p. 9).

Genesca, G., & Grifell, T. E. (1992). "Profits and Total Factor Productivity: A Comparative Analysis . *the International Journal of Management Science*, 553-568.

Grünberg, T. (2003). A review of improvement methods in manufacturing operation. *Work Study, 52*(2), 89-93.

Guhathakurta S., a. Y. (1993). International labor productivity. . *Cost Engineering Journal*, 15-22.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Gunasekaran, A., P. Cecille (1998). Implementation of Productivity improvement strategies in a small company

Heizer J., a. R. (1990). *Production and operations management :strategic and tactical* .

Huang S.H., D. J. (2003). Manufacturing productivity improvement using effectiveness metrics and simulatio analysis. *International Journal of Production Researc*, 513-527.

Imai, M. (1997). *Gemba Kaizen: A Commonsense, Low-Cost Approach to Management* (1st ed.). McGraw-Hill.

Jardine, A. &. (1973). *Maintenance, replacement and reliability*. Pitman.

Karuppana G.E. &PidugunV. M. (2013). Improvement of manufacturing performance measuring system and evaluation of overall resource effectiveness. American journal of applied science, 10(2), pg. 131-138

Khurana, A. & Talbot, B. (1998). The international process model through the lens of the global color picture tube industry. Journal of operations management, 16(2-3), pp.215-239

Lema. (1995). *Construction of labour productivity modeling.* Dar Elsalaam: University of Dar elsalaam.

Lowe, J. (1987). The measurement of productivity in the construction industry. *Construction Management and Economics*, 101-113.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Marcello Braglia, M. F. (2008). Overall equipment effectiveness of a manufacturing line (OEEML): An integrated approach to assess systems performance. *Journal of Manufacturing Technology Management*, 5.

Muchiri, P. (2006). Performance measurement using overall equipment effectiveness(OEE): literature review and practical application discussion. *International Journal of Production Research*, 4-5.

Murugesh, R. Devadasan, S. R. and Natarajan, R.(1997). Review and preview of productivity research and applications. Production planning and control 8(4), 310-320

Nachiaappan, R. M. & N. Anamtharaman (2006). Evaluation of overall line effectiveness in a continuous product line manufacturing system.

Nakajima, S. (1988). *Introduction to TPM: Total Productive Maintenance.* Cambridge, MA: Productivity press.

Nakajima, S. (1989). *Introduction to TPM.* Cambridge: Productivity Press.

Njiraini B.N, S.M Maranga, B. W Ikua (2012). Productivity improvement in small and medium machine manufacturing industries in Kenya. *Proceedings of the 2012 mechanical engineering conference on sustainable research and inovation, Vol. 4.*

Ohno, T. (1988). *Toyota production system: beyond large-scale production.* Productivity Press.

Olomolaiye P., J. A. (1998). *Construction productivity management.*

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Olomolaiye P., K. P. (1996). Factors influencing craftsmen's .

Pearl, J. (200). *Causality: Models, Reasoning and Inference.* Cambridge: Cambridge University Press.

Pyzdek, T. a. (2009). *The Six Sigma Handbook.* New York, NY: McGraw-Hil.

R.M. Nachiappan, N. A. (2006). Evaluation of overall line effectiveness (OLE) in a continuous product line manufacturing system. *Journal of Manufacturing Technology Management*, 99.

Rambaud, L. (2006). *8D Structured Problem Solving: A Guide to Creating High Quality 8D Reports.*

Rojas, M. (2003). Labor productivity driivers and oopportunities. *Journal of managemment in engineering*, 77-83.

Rouf, A. (1994). improving capital productivity through maintinance. *journal of operation and production management*, 44-55.

Särndal, C.-E. a. (1992). *Model assisted survey sampling.* . Springer-Verlag.

Shingo, S. (1989). *A study of the Toyota Production System.* Tokyo: Productivity Press.

Stephens, M. P. (2004). *PRODUCTIVITY AND RELIABILITY-BASED MAINTENACE MANAGEMENT.* New Jersey: Pearson PRENTCE HALL.

Swanson, Laura. (2001). Linking maintenance strategy to performance. International Journal of production economics, 70(3), 237-244.

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Tajiri, M., and Gotoh, E. (1992). TPM Implementation: A Japanese Approach, New York: McGraw-Hill

Teicholz, P. (2001). U.S. construction labor productivity trends, 1970-1998. *Journal of Construction management and engineering*, 197.

Tempelmeier, H. (2011). *Inventory Management in Supply Networks.* Norderstedt.

Thomas. (1991). labour productivity and work sampling: the bottom line. *Journal of Construction Engineering and Management*, 309-320. .

Vilasini P. P., Gamage J. R., Kahangamage U. P., &Thibbotuwawa N. (2012). Low productivity and related causative factors: A study based on Sri Lankan manufacturing organisations.

Wachira, I. N. (2001). Labour management in Kenya. . *Journal for the Department of building economics and management*.

Wacker, J. G., Yang, C. L. &Sheu, C. (2006). productivity of production labour, non-production labour, and capital. International journal of production economics, 103(2), pp.863-872.

Wilcox S., S. B. (2000). *Management and productivity.*

Womack, J., Jones, D. and Roos, D. (1996). lean Thinking Banish Waste and Create Wealth in your Corporation.

Zandin, K. B. (2001). Maynard's industrial Engineering Handbook (5th Edition).

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

APPENDIX

Regression analysis for in the labeling section

a)Change in productivity verses Change in availability

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Summary of analysis

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	1	0.4919	0.49192	16.50	0.003
Residual	9	0.2683	0.02981		
Total	10	0.7602	0.07602		

Percentage variance accounted for 60.8

Estimates of parameters

Parameter	estimate	s.e.	t(9)	t pr.
Constant	0.0189	0.0521	0.36	0.725
Change in availability	3.019	0.743	4.06	0.003

b) Change in productivity verses Change in performance in labeling

Summary of analysis

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	1	0.66738	0.66738	64.73	<.001
Residual	9	0.09280	0.01031		
Total	10	0.76018	0.07602		

Percentage variance accounted for 86.4

Message: the following units have high leverage.

Unit	Response	Leverage
2	0.395	0.47
8	-0.349	0.36

Estimates of parameters

Parameter	estimate	s.e.	t(9)	t pr.
Constant	0.0163	0.0306	0.53	0.607
Change in performance	1.615	0.201	8.05	<.001

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Changes in productivity verses Change in performance

Summary of analysis

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	1	0.66738	0.66738	64.73	<.001
Residual	9	0.09280	0.01031		
Total	10	0.76018	0.07602		

Percentage variance accounted for 86.4

Message: the following units have large standardized residuals.

Unit	Response	Residual
6	0.359	2.19

Message: the following units have high leverage

Unit	Response	Leverage
2	0.395	0.47
8	-0.349	0.36

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Estimates of parameters

Parameter	estimate	s.e.	t(9)	t pr.
Constant	0.0163	0.0306	0.53	0.607
Change in performance	1.615	0.201	8.05	<.001

Regression analysis

c) Change in productivity verses Change in availability and Change in performance

Summary of analysis

Source	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Regression	**2**	**0.69236**	**0.346181**	**40.84**	**<.001**
Residual	**8**	**0.06782**	**0.008477**		
Total	**10**	**0.76018**	**0.076018**		

Percentage variance accounted for 88.8

Estimates of parameters

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Parameter	estimate	s.e.	t(8)	t pr.
Constant	**0.0176**	**0.0278**	**0.63**	**0.545**
Change in availability	**0.988**	**0.576**	**1.72**	**0.124**
Change in performance	**1.286**	**0.264**	**4.86**	**0.001**

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Regression analysis in the cannery Section of DMKL

a) Change in productivity verses Change in availability

Summary of analysis

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	1	0.027397	0.027397	25.17	<.001
Residual	9	0.009797	0.001089		
Total	10	0.037194	0.003719		

Percentage variance accounted for 70.7

Estimates of parameters

Parameter	**estimate**	**s.e.**	**t(9)**	**t pr.**
Constant	0.01404	0.00998	1.41	0.193
Change in availability	2.898	0.578	5.02	<.001

b) Regression analysis for change in productivity verses Change in performance

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

Summary of analysis

Source	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Regression	1	0.036184	0.0361841	322.62	<.001
Residual	9	0.001009	0.0001122		
Total	10	0.037194	0.0037194		

Percentage variance accounted for 97.0

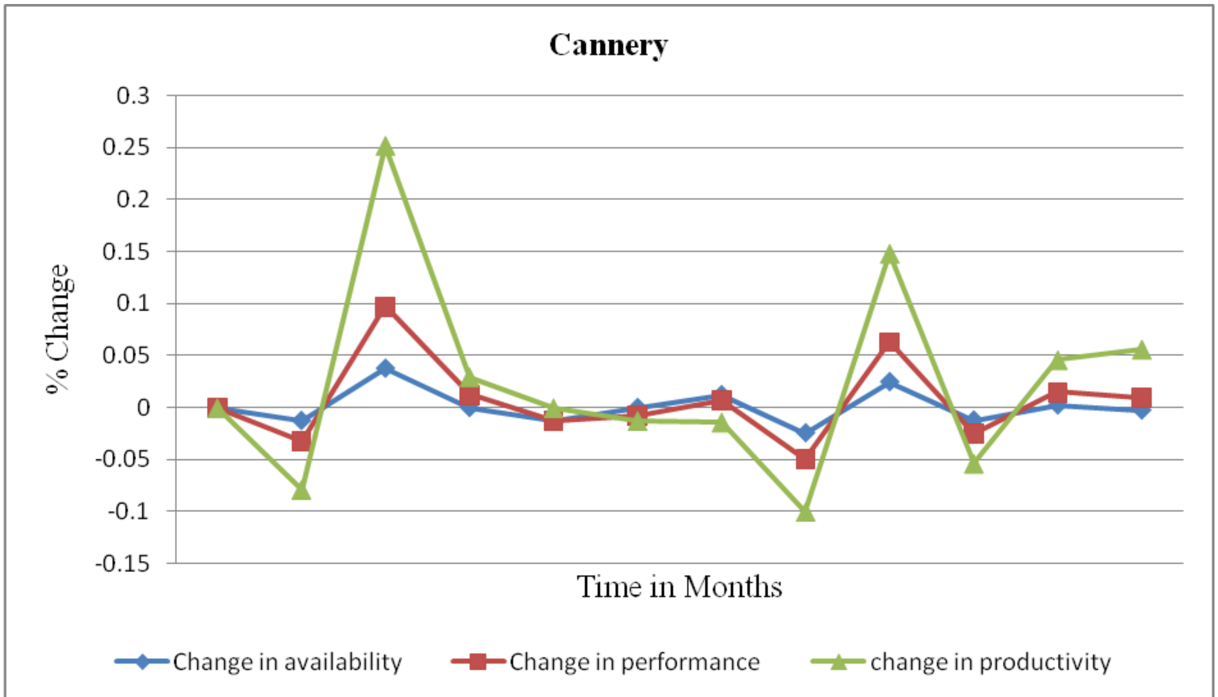
Estimates of parameters

Parameter	**estimate**	**s.e.**	**t(9)**	**t pr.**
Constant	0.00336	0.00329	1.02	0.334
Change in performance	2.390	0.133	17.96	<.001

Relationship between monthly changes in equipment performance and availability and how it affects productivity in labelling section

UNIVERSITY OF
NOLOGY

Relationship between monthly changes in equipment performance and availability and how it affects productivity in cannery section



UNIVERSITY OF
NOLOGY