UNIVERSITY OF NAIROBI

LEAN MANUFACTURING TOOLS AND TECHNIQUES IN INDUSTRIAL OPERATIONS: A SURVEY OF THE SUGAR SECTOR IN KENYA

BY

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DECLARATION

This research project is my original work and has not been presented for award of any degree in any University.

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This research project has been submitted for examination with my approval as University of Nairobi supervisor.

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DEDICATION

I dedicate this research project to my wife Doreen Wawuda Mwanake, my son Anderson and my mother Abigael Egwa Kisombe. Their love, care and support encouraged me to keep on going until end of the research project.

ABSTRACT

In the current era of globalization, industries are adopting new tools and techniques to produce goods to compete and survive in the market. The most daunting issue faced by manufacturers today is how to deliver their products or materials quickly at low cost and good quality. One promising method for addressing this issue is the application of lean manufacturing tools and techniques.

This research project examined the extent to which lean manufacturing tools and techniques are implemented by sugar manufacturing companies in Kenya, their impact on factory time efficiency and obstacles faced in the implementation process. The motivation of the study was based on the contribution of the sugar sector in the Kenyan economy.

The study was a census survey covering the eight sugar manufacturing companies registered by Kenya Sugar Board and those which have been in operation for more than three years. Data was collected from 150 employees in production, engineering and quality assurance departments of the eight sugar manufacturing companies using a structured questionnaire consisting mainly of closed-ended questions. The data collected was analysed using descriptive and inferential statistics.

The research revealed that companies in the sugar sector in Kenya have not given attention to all the key areas of lean manufacturing from a holistic perspective instead a piecemeal approach has been adopted. Conclusions drawn from the research was that the sugar manufacturing companies in Kenya lack understanding of lean manufacturing concepts and have therefore not reaped the full benefits of lean implementation.

Recommendations made were that the sugar companies in Kenya need a focused training on lean manufacturing for a better understanding among personnel and then give attention to the implementation of all areas of lean manufacturing from a holistic perspective in order to reap its full benefits.

The paper has provided insights into the implementation of lean practices in a Kenyan context using survey data as opposed to case studies, and provides further evidence that lean practices are significant in enhancing factory time efficiency.

Several practices and activities were selected associated with lean manufacturing and not specific to the sugar sector in Kenya. However, there may be other practices and activities that can be related to lean manufacturing and more relevant to the sugar sector that were not included in the study. There has been very little research in the area of lean manufacturing and therefore need for further research not only in the sugar sector but also in other areas of the Kenyan economy.

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LIST OF ABBREVIATIONS

5S – Sort; Straighten; Shine; Standardize and Sustain

ANOVA – Analysis of Variance

CGD – Centre for Governance and Development

COMESA – Common Market for Eastern and Southern Africa

EAC – East African Community

FTE – Factory Time Efficiency

HACCP – Hazard Analysis Critical Control Points

ISO – International Organization of Standardization

JIT – Just In Time

KESREF – Kenya Sugar Research Foundation

KIRDI – Kenya Industrial Research & Development Institute

KSB – Kenya Sugar Board

KSh – Kenya Shillings

KSI – Kenya Sugar Industries

KSST – Kenya Society for Sugarcane Technologists

SMED – Single Minute Exchange of Die

SPSS – Statistical Package for Social Sciences

TC/TS ratio – Tons of Cane Crushed/ Tons of Sugar Produced

TCD – Tons of Cane per Day

TPM – Total Productive Maintenance

TQM – Total Quality Management

VAT – Value Added Tax

VSM – Value Stream Mapping

WIP – Work In Process

CHAPTER ONE

INTRODUCTION

1.1 Background

Heightening challenges in today's global competition have prompted many manufacturing firms to adopt new manufacturing management strategies in order to enhance the firms' efficiency and competitiveness (Holweg, 2007). The most daunting issue faced by manufacturers today is how to deliver their products or materials quickly at low cost and good quality. One promising method for addressing this issue is adopting lean manufacturing practices (Taj, 2007).

Lean manufacturing, developed first at Toyota plant in Japan, has become a very popular production system improvement philosophy. It has been widely known and implemented since 1960 and according to Rinehart, J., Huxley, C. and Robertson, D. (1997) lean manufacturing will be the standard manufacturing mode of the 21st century. The principles of 'lean' focus on eliminating waste and non-value added activities in a process while maximizing the value-added tasks as required by the customer (Womack and Jones, 1996). Core principles used to achieve this include: specifying *value* from the end customer perspective, identifying the sequence of value-adding activities (*value stream*) for a given product, synchronizing processes to enable *flow* of physical products and information, pacing production to exactly meet customer demand (*pull*), and pursuing *perfection* through continuous improvement (Womack and Jones, 1996). A variety of specific techniques exist to support these activities, including: value stream mapping (VSM), total productive maintenance (TPM), just-in-time (JIT), Kanban, production smoothing, total quality management (TQM), standardization of work, single minute exchange of die (SMED), 5S and visual systems.

Lean manufacturing could be a cost reduction mechanism and if well implemented it will be a guideline to world class organization (Papadopoulu & Ozbayrak, 2005). Lean manufacturing comprise of universal management principles which could be implemented anywhere and in any company (Womack, J.P., Jones, D.T and Roos., D., 1990). It is now widely recognized that organizations that have mastered lean manufacturing methods have substantial cost and quality advantages over those who still practice traditional mass production (Pavnaskar, S.J., Gershenson, J.K. and Jambekar, A.B, 2003). Implementation of lean practices is frequently associated with improvements in operational performance measures. The most commonly cited benefits related to lean practices are improvement in labour productivity and quality, along with reduction in customer lead time, cycle time and manufacturing cost (Shah and Ward, 2003).Therefore, lean production is an intellectual approach consisting of a system of strategies which, when taken together, produce high quality products at the pace of customer demand with little or no waste.

1.1.1 Importance of the sugar sector to Kenya economy

The Kenyan sugarcane industry is a major employer and contributor to the national economy (KSB Strategic Plan 2009-2014). It is one of the most important crops alongside tea, coffee, horticulture and maize. Currently, the industry directly supports approximately 250,000 small-scale farmers who supply over 92 % of the cane milled by the sugar companies. An estimated six million Kenyans derive their livelihoods directly or indirectly from the industry (KSB Strategic Plan 2009-2014). In 2008, the industry employed about 500,000 people directly or indirectly in the sugarcane business chain from production to consumption. In addition, the industry saves Kenya in excess of USD 250 million (about KSh. 19.3 billion) in foreign exchange annually and contributes tax revenues to the exchequer (VAT, corporate tax, personal income taxes) (Ministry of Agriculture, 2010).

In the sugar growing zones, the sugar industry contributes to infrastructure development through road construction and maintenance; construction of bridges; and to social amenities such as education, health, sports and recreation facilities. The sugarcane industry provides raw materials for other industries such as bagasse for power cogeneration and molasses for a wide range of industrial products including ethanol (Ministry of Agriculture, 2010).

1.1.2 Challenges facing the sugar sector in Kenya

The sugar industry plays a significant role in socio-economic development of the Kenyan economy. Currently, there are 9 sugar factories in the country with a combined capacity to process 5 million metric tons of cane annually (KSB Strategic Plan 2009-2014). However, despite these investments, self-sufficiency in sugar has remained elusive over the years as consumption continues to outstrip supply (KESREF, 2010). The performance of the industry continues to face several challenges some of which include; high cost of production characterized by poor operational efficiencies with average sugar recoveries being 85%, which is less than the world average of 92%. Costs of local sugar production estimated at Ksh 46,000 per metric ton are almost double the Ksh 24,000 that countries like Swaziland in southern Africa register (KESREF, 2010).

Table 1.1 Cost of sugar production in COMESA and selected EAC countries

Country	Cost USD/ Tone
Kenya	415 – 500
Sudan	250 – 340
Egypt	250 – 300
Swaziland	250 – 300
Zambia	230 – 260
Malawi	200 – 230
Uganda	140 – 180
Tanzania	180 – 190

Source: Ministry of Agriculture **(2010)**: Kenya sugar industries strategic plan 2010-2014.

Kenya's sugar prices are higher than not only Brazil, but also Zambia and Malawi (Ophelie, 2006). However, geographical and climatic conditions in these two countries are similar to Kenya, which means that Kenya has no intrinsic reason for the high sugar prices. This observation by Ophelie means that there are approaches or techniques which many sugar producing countries have adopted to offer sugar at lower prices in the emergent liberalized sugar market (Table 1.1).

The following challenges and/ or gaps are recognized in the milling operations; irregular routine factory maintenance, low crushing capacity; low sugar extraction rates; slow adoption of new and appropriate technology; lack of industrial research; dilapidated processing equipment and inefficient factory operations (Ministry of Agriculture, 2010). Ministry of Agriculture also recognises the fact that there are glaring weaknesses in the manufacturing process which have led to losses within the system. This gives evidence that the sugar sector is uncompetitive because of wastes within the manufacturing process which have resulted to high cost of sugar production and in essence need to be eliminated.

The sugar sector will begin operating under a liberalized trade regime after the COMESA safeguard measures lapse in February 2012 (KESREF, 2010). In such environment, the industry will have to enhance its competitiveness along the entire value chain and reduce production costs by at least 39% to be in line with East African Community (EAC) partner states and Common Market for Eastern and Southern Africa (COMESA) sugar producing countries. This comparison clearly shows the lack of competitiveness of the Kenyan situation in a liberalized market.

1.2 Statement of the problem

There is very little research work that has been done on lean manufacturing practices as a way of improving operational performance especially factory time efficiency in the sugar sector in Kenya. KESREF, KIRDI and KSB scientists (Wawire, N.W., Muturi, S.M., Kuloba, P.W., Khisa, K., Kamau, J.K., Okoth, J.O., and Igara, F., 2006) carried out a study with an objective of addressing some of the challenges facing the sugar industry in its search for competitiveness and found that research activities were concentrated on agronomic and socio-economics with no published research on improvement of operational activities in sugar milling and processing. The researchers concluded that there are potential research capabilities that could be exploited through collaborative activities within KESREF, KIRDI, engineers and sugar technologists currently employed by the sugar industries and the local universities.

In 2008, KESREF scientists comprising of Wawire, N. W., Shiundu, R .M. and Mulama, P. carried out yet another study to assess the technical efficiency and costs of sugar processing aimed at improving performance and profitability in the Kenya sugar industry. The study found out that throughput of the factories was below the expected industry rate and below the installed capacities.

Capacity utilization in Kenyan sugar factories stands at less than 70% coupled with factory time inefficiencies translates into high production costs (CGD Bills Digest, 2005). By global standards, factory time efficiencies (FTE) stands at 91.7% while the average in Kenya is 57% and best performing factory manages just over 86%. Indeed, lost time has been cited as the single largest operating problem of the sugar factories in Kenya (CGD Bills Digest, 2005). None of the individual factories for example achieved their set production targets for year 2007 (Wawire et al, 2008).

The study by KESREF scientists concluded that to improve on factory performance, timely maintenance of the milling and processing plants is required with a need to assess the benefits and costs of scheduled maintenance (every year for six weeks) against maintenance while plant is on production.

Currently, there is no published research on adoption of lean manufacturing tools and techniques in the sugar sector in Kenya and this research will serve as the first one in the industry.

This research project was informed by the gap that exists between sugar industry operations and implementation of lean manufacturing practices in improving factory time efficiency bringing to the fore the following questions;

1. To what extent have sugar manufacturing industries in Kenya implemented lean manufacturing tools and techniques?

2. To what extent have lean manufacturing tools and techniques helped sugar manufacturing industries in Kenya improve factory time efficiency?

3. What obstacle(s) have sugar manufacturing industries in Kenya faced while implementing lean manufacturing practices?

1.3 Research objectives

From the research questions, the overall objective of the research project was to examine the extent to which lean manufacturing tools and techniques were implemented by the eight sugar manufacturing industries in Kenya.

The specific objectives were:

1. To examine the extent to which sugar manufacturing industries in Kenya have implemented lean manufacturing tools and techniques.

2. To examine the extent to which lean manufacturing tools and techniques have helped sugar manufacturing industries in Kenya improve factory time efficiency.

3. To identify obstacle(s) faced by the sugar manufacturing industries in Kenya while implementing lean manufacturing practices.

1.4 Value of the study

The Kenyan sugarcane industry is a major employer and contributor to the national economy and any study that is done to improve this sector is taken as of value to the economy at large. Sugarcane is one of the most important crops alongside tea, coffee, horticulture and maize. Currently, the sugar industry directly supports approximately 250,000 small-scale farmers and an estimated six million Kenyans derive their livelihoods directly or indirectly from the industry.

The research paper will contribute to a great extent in the realization of Kenya vision 2030 through analysis of operational performance of the sugar manufacturing sector which is a key player in the Kenyan economy. The research findings will also be useful to various stakeholders in the sugar sector including the Millers, the Government of Kenya through the Ministry of Agriculture, Kenya Sugar Board and Kenya Sugar Research Foundation, Researchers in sugar technology and Kenya Society for Sugarcane Technologists.

Currently, there is no published research on lean manufacturing in the sugar sector in Kenya and the findings of this research project will contribute to new knowledge as far as adoption of lean manufacturing tools and techniques in the sector is concerned.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin of lean

Lean evolved as a comprehensive business strategy in Toyota Motor Company after World War II as a solution for the limited resources available to Japanese manufacturers at the time, in contrast with the vast resources available for the manufacturers in United States (Suarez and Pujol, 2005). Lean manufacturing was originally called "Just-in-Time" or the "Toyota Production System." The term "lean" was first coined by Womack et al. (1990) in their book *The Machine that Changed the World*. The individual principles and practices of lean, although very fundamental in concept, were developed over a 90-year period of time (Smith and Hawkins, 2004) Japan did not invent individual lean practices with the Toyota Production System. Instead, they adapted and improved what they had learned from American automobile manufacturers, primarily Henry Ford, and other American industries (Smith and Hawkins, 2004). The concepts included: waste elimination; standardized work practices; just-in-time systems and doing it right the first time. Toyota followed these concepts to build a comprehensive system.

2.2 What is lean manufacturing?

Lean manufacturing is defined as a practice of eliminating waste in every area of production including customer relations (sales, delivery, billing and product satisfaction), product design, supplier network, production flow, maintenance, engineering, quality assurance and factory management (Smith and Hawkins, 2004). In lean manufacturing, waste is identified as anything that does not add value to the process or service delivered to the customer.

The resounding principle of lean manufacturing is to reduce cost through continuous improvement that will eventually reduce the cost of services and products, thus growing more profits (Womack et al, 1990). Lean focuses on abolishing or reducing wastes and on maximizing or fully utilizing activities that add value from the customer's perspective. From customer's perspective, value is equivalent to anything that the customer is willing to pay for in a product or the service that follow. So the elimination of waste is the basic principle of lean manufacturing (Ohno, 1997; Shingo, 1997).

The Lean approach consists of various practices, which aim to improve efficiency, quality and responsiveness to customers. Todd (2000) defines lean manufacturing as an initiative whose goal is to reduce the waste in human effort, inventory, time to market, and manufacturing space to become highly responsive to customer demand while producing world class quality products in the most efficient and economical manner. Lean manufacturing is about creating more value for customers by eliminating activities that are considered waste. This implies that any activity that consumes resources, adds costs or time without creating customer value is a target for elimination.

2.3 Benefits of lean manufacturing in industry

Companies that have adopted lean manufacturing have typically cut inventories and cycle time by 50% in each wave of their lean program. From literature it is evident that many concepts of lean manufacturing such as JIT, Kanban, Production smoothing, TPM and TQM have been implemented in more than one process industry and resulted in huge benefits (Shah and Ward, 2003). For example, JIT concepts were successfully applied in a DuPont textile plant to decrease WIP inventory by 96% and reduced working capital by

$2 million (Billesbach, 1994). Similarly, in the Dow Chemical Company, JIT deliveries, kanban and other lean methods resulted in a 25% increase in demand forecasting accuracy, a 25% reduction in distribution lead times, and an $882,750 decrease in working capital (Cook and Rogowski, 1996).

A series of simulation experiments in a steel mill suggested that VSM, Kanban, JIT, Production smoothing, TPM, Setup reduction, 5S and Visual Control would result in a decrease of production lead time from 48 days to 15 days and a reduction of WIP inventory from 96 to 10 coils for a particular portion of the process (Abdulmalek, F., Rajgopal, J., Needy. K.,2006) In a multi-product chemical manufacturing process, VSM, Kanban and Visual Control resulted in a reduction of overall supply chain cycle time by 50%, a reduction of inventory by 30% and an increase in customer order accuracy by 25% (Melton, 2005).

2.4 Lean tools and techniques for manufacturing

There are many lean tools and techniques which help manufacturing organizations to implement lean manufacturing practices (Tiwari, A., Turner, C., and Sackett, P., 2007). They are interrelated in their ability to reduce cost through enhanced efficiency, which contributes to their influence on operational performance (Shah and Ward, 2003). According to Herron and Braident (2007), lean tools should not be implemented in isolation; they were developed for a reason, which was to support an overall strategy. Bhasin and Burcher (2006) also suggested that it was better to embrace more lean tools rather than practicing one or two isolated ones. Each of these tools and techniques are briefly discussed.

2.4.1 Value stream mapping

Value stream mapping (VSM) is a lean manufacturing technical methodology applied to interpret the flow of materials and information currently needed to transit goods or services to the end consumer. Both the spare parts and sub-working procedures in the working process from raw material to the finishing goods/completed products are involved (Rother and Shook, 1999). Womack and Jones (2003) described the VSM as a simple process of directly observing the flows of information and materials as they now occur, summarizing them visually, and then envisioning a future state with much better performance. The goal of VSM is to identify all types of waste in the value stream; decrease and eliminate these wastes (Rother and Shook, 1999).

Value stream mapping can serve as a good starting point for any enterprise that wants to be lean. Value stream mapping helps you visualize more than just the single process (e.g. assembly, welding) in production; you can see the entire flow (Rother and Shook (1999) VSM helps you not only see your waste but also its sources in the value chain and provides a common language for talking about manufacturing processes. It forms the basis for an implementation plan. By helping you design how the whole door-to-door flow should operate a missing piece in so many lean efforts, value stream maps become a blueprint for lean implementation. Value stream maps serve as a critical tool that can reveal substantial opportunities to reduce costs improve production flow, save time and reduce inventory.

2.4.2 Just-in-time (JIT)

JIT manufacturing is a management concept which assures improvement through elimination of waste like waiting time and overproduction. JIT manufacturing is a method whereby the manufacturing lead time is greatly shortened by maintaining conformity to changes by having all process produce the necessary parts at the necessary time, and having on hand only the minimum stock necessary to hold the process together (Sugimori, Y., Kusunoki, K.,& Uchikawa, S., 2008). Following are the requirements to produce necessary parts/ products at the necessary time (Dreyfus, L.P., Ahire, S.L. and Ebrahimpour, M., 2004); reduced setup time; total productive maintenance; multi skilled employees; Kanban system; uniform plant loading; quality control and quality circles.

A company establishing JIT flow throughout the manufacturing process can have zero inventories (Ohno, 1988). The performance metrics improved using JIT implementation are cost and delivery time (Huang., Rees., & Taylor III., 1983).

2.4.3 Total productive maintenance (TPM)

TPM is an initiative for optimizing the reliability and effectiveness of manufacturing equipment (Smith and Hawkins, 2004). TPM is a method to improve overall efficiency (effectiveness) of equipment through a complete productive maintenance system for the entire life of the equipment, with participation of all employees from higher management to daily employees, through motivation or voluntary participation (Tsuchiya, 1992). The goal of TPM is to reduce equipment breakdowns, defects and safety problems (Ravishankar, G., Burczak, C. and Vore, R.D., 1992). TPM combines the features of productive and predictive maintenance with innovative management strategies (Singh, R.K., Choudhary, A.K., Tiwari, M.K., and Maull, R.S., 2006a). Equipment must be given proper attention and maintained periodically, which is the main aim of TPM.

One of the key strategies of TPM is employee involvement, including encouraging employees to treat the equipment like “it is your own” i.e. having employees perform maintenance strategies. TPM requires support from top management to be effective (Smith and Hawkins, 2004). TPM will have a major impact on failure time reduction and increases the machine availability. According to practitioners TPM dramatically improves (Smith and Hawkins, 2004) productivity; equipment availability; quality and safety of both employees and machinery. The performance metrics improved by implementing TPM are cost, quality and delivery time (Mckone., Schroede., Cua., 2001).

2.4.4 Kanban

Kanban, which means “signboard” in Japanese, was first developed by Taichi Ohno to control production between processes and implement Just-in-Time (JIT) manufacturing at Toyota manufacturing plants in Japan. Kanban is an execution tool rather than a planning tool. Kanban is a signalling card which has information about amount of products to be produced, origin of the product, and destination of the product. The Kanban methodology is a material presentation method designed to simplify material handling and inventory management (Ohno, 1988). Instead of stacking the materials issued to the production near the line in larger quantities, smaller quantities of materials are physically present at point of usage on the line and replenished only when a Kanban or signal is generated (Hobbs, 2004). By implementing Kanbans, Toyota manufacturing was able to reduce work-in-process (WIP) and the cost associated with holding inventories (Gross and Mclnnis, 2003). Other benefits of Kanban (Hobbs, 2004) include: reduced inventory; improved flow; reduced or eliminated overproduction; improved responsiveness to change in demand and increased ability to manage the supply chain.

From the benefits of Kanban it can be observed that performance metrics such as cost, delivery time and flexibility can be improved. For instance, due to improved flow and improved responsiveness to change in demand there will be improvement in delivery time and flexibility. By implementing Kanban there will be zero inventory, by which the inventory holding cost will be reduced, thus also reducing organizational cost (Hobbs, 2004).

2.4.5 Production smoothing

Production smoothing is a process in which the production level for each part is kept as constant as possible across and within days (Abdulmalek et al, 2006). In his book *Toyota Production System*, Taiichi Ohno (1988) explains how production smoothing evolved.

The main advantage the manufacturing unit gains by implementing production smoothing is that the output will be the exact amount as required at the required time and there will be reduced chance of accumulating inventory. From the benefits of the production smoothing it can be observed that there will be significant reduction in cost holding the inventories.

2.4.6 5S System

5S is the name of a workplace organization methodology and a popular tool used in lean manufacturing environments to clean up and organize the business environment (Sun and Yanagawa, 2006). 5S stands for; sort, straighten, shine, standardize and sustain (Lean Manufacturing Solutions, 2008). Many organization workplaces often have the disorder problems because of the larger numbers of people working together and countless hours of time engaged in very costly non-value adding activities. Such problems exacerbate the business administrative work environment and these day-to-day workplace organization issues manifest into bigger problems such as: (Chapman, 2005) long lead times; low productivity; high operating costs; late deliveries, unreasonable ergonomics; space constraints; frequent equipment breakdowns and hidden safety hazards.

2.4.7 Visual display and controls

Visual control enables anyone to more easily understand what is going on in the shop floor, and also indicates the safety lines and location for every tool. Operations in companies today have become more complicated, involving global supply chains and dispersed operations. So “dashboards” have been developed for information displays to report the current state of the company’s production, service provision or processes. Computer displayed graphical outputs of the metrics, i.e., key performance indicators, are some of the examples of visual control tools. Visual control tools ensure an effective means of communication of information such as customer requirements, production schedules, and the aims and objectives set by management across the enterprise (Parry and Turner, 2006). Through a standard visual work order employees immediately know exactly where to go and what to do. This means they begin their duties instantly, and this improves shift’s efficiency and productivity. In other words visual tools provide all workers with clear and concise communication.

2.4.8 Standardization of work

A very important principle of waste elimination is the standardization of worker actions. Standardized work basically ensures that each job is organized and is carried out in the most effective manner. By doing this one ensures that line balancing is achieved, unwarranted work-in- process inventory is minimized and non-value added activities are reduced. A tool that is used to standardize work is “takt” time. Takt (German for rhythm or beat) time refers to how often a part should be produced in a product family based on the actual demand. The target is to produce at a pace not higher than the “takt” time (Mid- America Manufacturing Technology Centre press release, 2000). Takt time is calculated based on the following formulae (Feld, 2000):

$$\text{Takt Time (TT)} = \frac{\text{Available production time per day}}{\text{Customer demand per day}}$$

2.4.9 Total quality management (TQM)

TQM is defined as a process that improves the quality of a product by continuous improvement in the manufacturing process through effective feedback from employees (Khurram & Hashmi, 2006). A TQM process cannot be implemented without top management commitment. Naguib (1994) reviews the basic concepts of TQM, which are; customer satisfaction; continuous improvement; total quality control and training. The following results are obtained from a company that implements TQM (Naguib, 1994); improved quality of the product; increased productivity; 100% customer satisfaction and improved employee satisfaction.

2.5 Manufacturing systems – continuous process industry and lean

A big part of the success of lean manufacturing has come from the automotive industry especially in the assembly line type process. The challenge today is to adapt the ideas of lean and implement them in a continuous manufacturing environment like in the sugar industries. High volume, low variety products and inflexible processes characterize the continuous process manufacturing environment. Managers have been slow to adapt the ideas of lean into these processes. The fear comes from inflexibility of the process where it is more difficult to reduce the lot size. For example, in the continuous process industry set up times are typically long and it is costly to shutdown the process for a changeover (Sandras, 1992).

It is evident from literature that the lean tools that previous research suggests most applicable for process industries are JIT, Kanban, and TPM plus the universal lean tools such as VSM, Standard work, 5S and Visual control. However, these results need to be verified systematically, particularly across different production system types within the process industry.

2.6 Success factors in lean implementation

Crute, V., Ward, Y., Brown, S. & Graves, A. (2003) in their longitudinal case study of two plants in the aerospace industry argued that lean philosophy and techniques require adoption of the entire system in a holistic manner rather than applying techniques in a piecemeal fashion. Womack and Jones (1996) suggest that managers have drowned in techniques as they try to implement isolated parts of lean system without understanding the whole. On the other hand this more tentative or piecemeal approach is being adopted mainly as a result of resistance from the employees to the new ideas. The more focused training gives evidence for a better understanding among personnel of the key principles of waste elimination and flow of value.

Organizational culture is an essential element in lean implementation process and high performing companies are those with a culture of sustainable and proactive improvement efforts (Achanga, P., Shehab, E., Roy, R. and Nelder, G., 2006). Changes of mindset gives people an aim in their working life and have the potential to change attitudes, so that the employees begin to think differently and are more willing to contribute to company's improvement initiatives. Stronger management control makes the organization structure bureaucratic, which makes difficult the change from the existing ways of doing things (Motwani, 2003). Consistency in management commitment is emphasized as important element in effective implementation of changes in organizations (Kotter, 2007). It is highly desirable to have a certain degree of communication skills throughout the company, long-term focus of management and strategic team while implementing a new initiative (Achanga et al, 2006).

Timing for performance improvements is also considered as a significant factor for organizational change. The companies need to be prepared for the lean transformation, but at the same time manage change requires fast reaction with the implementation activities even taking a risk and later deal with consequences. (Crute et al. 2003)

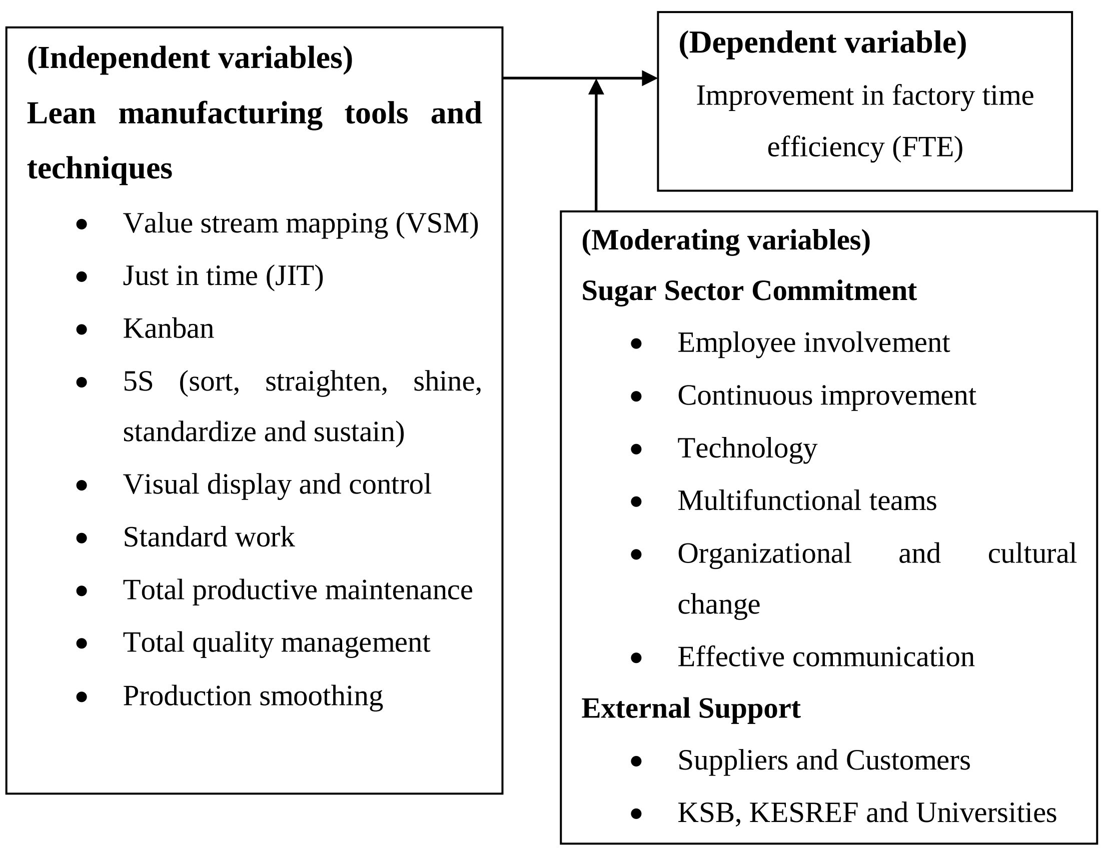
Financial capabilities of companies are one of the critical factors for successful implementation of lean (Achanga et al. 2006). Financial resources are needed for employee training, external consultants and many other inputs to the programs. Sometimes even production of firms may be interrupted as a result of the employees training in the new techniques. The managers would rather refuse unnecessary loss of resources especially if they do not anticipate immediate returns (Ibid, 2006). Lean changes need to be focused on the specific product value stream, so that the control over resources to be dependent mainly on the improvement team (Crute et al. 2003). Staying competitive requires the use of intellectual capital and ability to innovate and differentiate (Czabke, Hansen & Doolen, 2008). Most companies experience difficulties after employing people with low skills levels, who do not foster the ideology of skill enhancement.

If managers apply these concepts collectively they can reap the full benefit of lean techniques and significantly improve their products' competitive edge (Motwani, 2003).

2.7 Conceptual framework

The conceptual framework is comprised of lean manufacturing tools and techniques as independent variables, improvement in factory time efficiency of the sugar industries as dependent variable and sugar sector commitment and external support as moderating variables as shown in Figure 2.1

Figure 2.1: Conceptual framework for lean manufacturing in the sugar industries



Source: Author **(2012)**

The critical elements on sugar sector commitment are management leadership and commitment, employee empowerment & involvement, continuous improvement, building multifunctional teams, adoption of new technology, effective communication and organizational & culture change. These elements are considered as prerequisites for lean manufacturing (Ferdousi, 2009 and Achanga et al., 2006). As an example, top management is considered as a recipe to success in any new management system (Achanga et al. 2006; Bamber & Dale, 2000). In addition, the transition from traditional to lean manufacturing implementation should be driven by the top management team (Boyer & Sovilla, 2003).

Lambert, D.M., Cooper, M.C. and Pagh, J. (1998), suggest that the structure of activities and processes within and between companies is crucial for achieving superior competitiveness and profitability. It is vital that lean suppliers receive on time and stable schedules so that materials and parts can be secured and delivered as when required (Keller, A.Z., Fouad, R.H. and Zaitri, C.K.1991). To achieve waste reduction, coordination of activities is critically important (Xu and Beamon, 2006). Part of building coordinated links between chain partners involves communication and information sharing with the intention of influencing trading partners to forge strong integrative relationships (Holden and O'Toole, 2004). To achieve these strong relationships requires an understanding of the expectation of business partners (Hausman, 2001). Participation in such relationships is recognised as contributing to firm operational performance (Frazier, 1999). An example of this dependence is the lean supply concept, which enables the supply chain to hold minimal inventories while still being able to react to pull strategies in relation to customer demand.

Another lean manufacturing feature is the search for continuous improvement in products and processes (Oakland, 1993). The adoption of lean integration principles between firms requires continuous effort of improvement using mutual-focused relationships. Lean also relies on relationships to enable these practices to be carried out (McIvor, 2001).Success in lean implementation involves making appropriate responses to technological changes and learning from other organizations that have achieved the best practices in the industry continuously (Freeman and Perez, 1988). In innovative organizations, employees should be trained in multiple skills and possess redundant capabilities. The contents of the individual tasks should be enlarged and enriched, and the continuous improvement of the tasks should be an important aspect of work. These principles increase creativity (van De Ven, 1986).

Factory time efficiency in the context of the sugar industries in Kenya is the index that measures the ability of a factory to sustain operations throughout the year without interruptions. By global standards a well-run factory within minimum downtime should operate for 22 hours non-stop in a day (CGD Bills Digest, 2005). Factory time efficiency is an important pointer to operational performance of a manufacturing industry. The role of the sugar industries is to make a fair return on investment through efficient operation of the mills for the production of sugar and other products for sale. All factories need to operate optimally through efficient modern style management, adoption of new technology and carry out regular condition maintenance.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research design

A research design provides a framework for the collection and analysis of data. This research project employed a survey research design. A census survey was employed by collecting data from all the eight (Muhoroni, Chemelil, Mumias, South Nyanza, West Kenya, Nzoia, Soin and Kibos) sugar manufacturing industries to determine the extent of implementation of lean manufacturing tools and techniques and their impact on factory time efficiency. Survey design is most appropriate where a study is set to determine existence and extent of a problem or phenomenon (Richard and Chava, 1996).

3.2 Population

The eight sugar manufacturing companies registered by the Kenya Sugar Board and currently operating were covered in the study. Butali Sugar Company was not covered in the survey because it is still in its commissioning stage and the topic under study required companies who have been in operation for at least three years to ensure accuracy and authenticity of the information provided.

3.3 Sample design

The study purposively selected the operations division of each of the eight sugar manufacturing industries in Kenya. Each operations division consists of production, engineering and quality assurance departments. The sugar companies were then categorised into two; small and medium sized sugar manufacturing industries for those with 800 employees and below and large sugar companies for those employing over 800 employees. For small and medium size sugar companies each of the three departments were issued with 5 questionnaires and for large companies each department was issued with 15 questionnaires bringing a total sample size of 240 respondents. Employees in production, engineering and quality assurance departments were targeted because these are the people with the most knowledge of the subject under study.

3.4 Data collection

The study used primary data obtained through a structured self-administered questionnaire on employees in operations division of the eight sugar manufacturing companies. A five-point likert scale was used in the questionnaire with 1 indicating "not at all" and 5 indicating "to a great extent". The questionnaire contained four parts. Part A of the questionnaire asked respondents to give a general profile of themselves and their companies. Part B of the questionnaire asked respondents the extent to which lean manufacturing practices/activities were implemented in their companies from a given list of practices and activities. Part C asked the respondents to indicate the level of their company's factory time management as described by various statements given and lastly part D of the questionnaire asked the respondents to indicate obstacles they have faced while implementing lean from a given list of obstacles related to lean implementation.

A survey package was submitted by the researcher in person to the targeted respondents in the eight sugar operating factories. Each survey package included one questionnaire form of the survey instrument and a cover letter introducing the researcher. The questionnaires were later collected by the researcher after a period of one week.

3.5 Data analysis

Descriptive and inferential statistics were used to analyse data collected in the survey. Statistical Package for Social Sciences (SPSS 17.0) was used for the data analysis. Descriptive statistics is used to describe basic features of data collected in a study and provide simple summaries about the sample and the measures. Together with simple graphic analysis, they form the basis of virtually every quantitative analysis of data (Muganda, 2010).

The responding sugar companies were classified into three categories namely government owned, public owned and private owned and again into two; small and medium and large companies. Three regression models were run for these three categories of companies to investigate the effect of lean manufacturing practices and activities on factory time efficiency. Regression analyses provide a measure of the effect of one variable or more variables on another variable (Hinton, 2004).

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

The purpose of this research project was to examine the extent to which lean manufacturing tools and techniques are implemented by sugar manufacturing industries in Kenya, their impact on the firms' time efficiency and obstacles faced by the industries while implementing lean.

A survey questionnaire was used to explore 12 key lean manufacturing practices and activities namely; employee involvement, supplier involvement and JIT, customer involvement, new technology, kanban, 5S, production smoothing, standardization of work, total preventive maintenance, value stream mapping, total quality management and visual display and controls. A total of 240 questionnaires were distributed to production, engineering and quality assurance departments of the eight sugar manufacturing companies and 150 were filled returning a response rate of 62.5%. Descriptive and inferential statistics were used to analyse the data collected and Statistical Package for Social Sciences (SPSS 17.0) was used for this purpose.

The sugar sector in Kenya is considered a labour intensive sector with over 5158 people employed in the sugar factories in 2008 (KSB Strategic Plan 2009-2014) with Mumias Sugar Company Limited employing a workforce of 1700 people in 2009 (Mumias sugar company financial statements, 2009). From this background, the sugar companies were categorized into small and medium size for those with below 800 employees and large for those employing over 800 employees.

4.2 Key characteristics of respondents

Part A of the questionnaire asked the respondents to give their general characteristics and those of their organizations including experience in terms of years worked, number of people employed, ownership and whether their operations were certified by any of the ISO standards.

Table 4.1 shows that 50% of the sugar companies represent large companies with employee population crossing over the 800 mark and the other 50% represents small and medium size companies with employee population below 800.

Table 4.1 Size of sugar companies based on employee population

Category	**No. of Employees**	**No. of companies**	**Percent %**	**Valid percent**	**Cumulative percent**
Small and Medium	Less than 800 employees	4	50.0	50.0	50.0
Large	More than 800 employees	4	50.0	50.0	100.0
	Total	8	100.0	100.0	

Source: Primary data

Table 4.2 shows that 71.2% of government owned sugar companies have more than 800 employees meaning that they are large enterprises while 100% of privately owned sugar companies have less than 800 employees meaning that they are small and medium companies. The results also show that 100% of public owned companies are large enterprises with employee population above 800.

Table 4.2 Number of employees based on company ownership

	Govt. Owned (%)	Public owned (%)	Private owned (%)
No. of companies	4	1	3
Less than 800 employees	28.8	0.0	100.0
More than 800 employees	71.2	100.0	0.0
Total	100.0	100.0	100.0

Source: Primary data

Table 4.3 shows that among the respondents over 75% have more than six years of working experience in the sugar industry. This was important for ensuring the accuracy and authenticity of the information they provided in the study.

Table 4.3 Respondents experience in years

Experience in years	Frequency	Percent	Valid percent	Cumulative percent
Less than two years	14	9.3	9.3	9.3
2 to 5 Years	22	14.7	14.7	24.0
6 to 10 Years	68	45.3	45.3	69.3
Over ten years	46	30.7	30.7	100.0
Total	150	100.0	100.0	

Source: Primary data

In terms of ownership, table 4.4 shows that 50% of the responding companies indicated that they were Government owned, 37.5% indicated that they were privately owned with the remainder (12.5%) indicating that they were publicly owned.

Table 4.4 Ownership of sugar companies

Ownership	No. of companies	Percent	Valid percent	Cumulative percent
Government	4	50.0	50.0	50.0
Public	1	12.5	12.5	62.5
Private	3	37.5	37.5	100.0
Total	8	100.0	100.0	

Source: Primary data

Table 4.5 shows that five sugar companies representing 62.5% of the total number of sugar companies in Kenya are ISO 9001:2008 certified. Out of this figure, 12.5% are publicly owned and 50% are government owned. All privately owned sugar companies are not ISO certified while all government owned sugar companies are ISO certified.

Table 4.5 Status of ISO certification

	Govt.	Public	Private	Total
ISO certified (frequency)	4	1	0	5
Percent	50.0	12.5	0.0	62.5
Not certified (frequency)	0	0	3	3
Percent	0.0	0.0	37.5	37.5

Source: Primary data

4.3 Implementation of lean tools and techniques in the sugar manufacturing companies

In part B of the questionnaire, the respondents were asked about the implementation of twelve management practices that are commonly associated with lean manufacturing. The likert scale items in the questionnaire were summed together to measure a single latent variable for the 12 key lean manufacturing practices and activities listed in section 4.1. For the twelve management practices, percentages for the level of lean implementation were computed based on company ownership and then a summary of mean, standard deviation, variance and percentages for the responses were computed to determine the extent of implementation.

4.3.1 Employee involvement practices

Table 4.6 gives responses on employee involvement practices as given by respondents from the three categories of companies. The responses show that 80.1% of the respondents in government owned sugar companies agreed that their employer has involved them in various levels of decision making in the business while only 9.1% of the respondents in privately owned sugar companies agreed that they too have been involved. Employees who are aware of the processes and who are empowered are essential since people are the key element in lean manufacturing. The phrase “No one knows the job better than those who do it” indicates that the person who is experienced in his/her job is most likely to have a better understanding on it and therefore the need for involvement.

Privately owned sugar companies have not involved their employees in process improvement efforts, in problem solving teams and in driving suggestion programs. It is noted that all the privately owned sugar factories have not implemented any of the ISO system standards and this could explain why employee teams are non - existent. The organizational structures in these privately owned sugar firms might have played a role in that these companies are family businesses and decisions are made at the corporate level with no involvement of employees at the shop floor.

Table 4.6 Responses on employee involvement practices

Employee involvement practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government Owned	0.0	5.0	15.1	76.3	3.8	100.0
Public Owned	5.4	10.8	43.3	40.5	0.0	100.0
Private Owned	12.1	57.6	21.2	6.1	3.0	100.0

Source: Primary data

4.3.2 Supplier involvement and JIT practices

Responses received on supplier involvement and JIT practices were surprising. Table 4.7 shows that supplier involvement and JIT practices is an area that many respondents did not have information or did not want to talk about. Over 76% of respondents neither agreed nor disagreed whether supplier involvement and just in time practices were implemented in their companies. Respondents were asked whether suppliers were involved in material requirement planning and whether they were directly involved in new product development process. Considering the sugar sector in Kenya little product development activities are carried out and supplier activities are bound to be handled by different departments apart from those surveyed and this might have led to the responses received. However, lean goes beyond departments since successful implementation relies on close relationship with suppliers. It is vital that suppliers receive on time and stable schedules so that materials and parts can be secured and delivered.

Table 4.7 Responses on supplier involvement and JIT practices

Supplier involvement and JIT practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	21.2	76.3	0.0	2.5	100.0
Public owned	0.0	10.8	78.4	10.8	0.0	100.0
Private owned	3.0	6.1	78.8	12.1	0.0	100.0

Source: Primary data

4.3.3 Customer involvement practices

Table 4.8 shows that customer involvement practices have been implemented to a great extent by the three categories of companies. 93.7% of the respondents in government owned sugar companies agreed that customers have been involve in current and future product offerings and that they give feedback on quality and delivery performance. Respondents in privately owned sugar companies (90.9%) also agreed that they have involved their customers to a great extent. Surprisingly, Mumias Sugar Company the only public owned company in the sugar sector has to a lesser extent (48.7%) involved its customers in seeking for feedback on quality and delivery performance and in current and future product offering. The company seems to have a very elaborate management system that aids in giving feedback for future product offering that the larger company workforce is not involved in. The company is ISO certified and seem to enjoy customer confidence a great deal though this might be detrimental to the business in the long run. It is important to involve customers in areas of quality and delivery performance even in such high levels of customer satisfaction.

Table 4.8 Responses on customer involvement practices

Customer involvement		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	1.3	5.0	76.3	17.4	100.0
Public owned	0.0	10.8	40.5	43.3	5.4	100.0
Private owned	0.0	0.0	9.1	57.6	33.3	100.0

Source: Primary data

4.3.4 Adoption of new technology

Success in lean implementation involves making appropriate responses to technological changes and learning from other organizations that have achieved the best practices in industry continuously. Table 4.9 shows that 73.0% of respondents in the public owned sugar company agreed that new technological changes have been adopted while 66.6% in the private owned companies agreed.

Government owned companies have not adopted new technology in their processes as over 97.5% of the respondents disagreed. This might be due to the bureaucracy involved in decision making in government owned companies. Government owned sugar companies were established more than thirty years ago and the technology employed then is no longer feasible in this era and they have not embraced modern maintenance practices as evidenced by low uptake of total productive maintenance practices (6.4% table 4.13). The machinery in these government owned companies is old and difficult to modernise considering the kind of heavy machinery involved in sugar processing.

Table 4.9 Responses on adoption of new technology

Adoption of new technology		Extent of adoption Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Govt. owned	21.2	76.3	0.0	0.0	2.5	100.0
Public owned	0.0	0.0	27.0	62.2	10.8	100.0
Private owned	18.2	15.2	0.0	57.5	9.1	100.0

Source: Primary data

4.3.5 Kanban practices

Table 4.10 shows that Kanban practices have been implemented to a great extent by government owned sugar companies (73.8%) followed by public (56.8%) and privately owned at 66.7%. Kanban is an execution tool rather than a planning tool. Kanban is a basic practice involving a signalling card which has information about amount of products to be produced, origin of the product, and destination of the product and can be implemented at any level in the manufacturing process.

Table 4.10 Responses on kanban practices

Kanban practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Govt. owned	0.0	0.0	26.2	71.3	2.5	100.0
Public owned	0.0	5.4	37.8	51.4	5.4	100.0
Private owned	0.0	12.1	21.2	57.6	9.1	100.0

Source: Primary data

4.3.6 5S practices

5S is a workplace organization methodology and a popular tool used in lean manufacturing environments to clean up and organize the business environment. Table 4.11 shows that privately owned sugar companies have to a great extent implemented 5S practices (100%) as opposed to government owned sugar companies (29.5%). 5S is a lean manufacturing tool involving to a larger extent employee safety and ergonomics and its implementation means fewer liabilities as a result of reduced factory accidents. Privately owned sugar factories are family businesses and largely foreign owned thus negative publicity is a crucial aspect to safeguard. There is very low implementation of 5S practices by government owned sugar companies because of the fact that they are owned by the government and negative publicity and keeping a good name might not be a priority for these sugar companies. These government sugar companies are all ISO certified and this is a pointer to the fact that ISO certification has to a greater extent not improved operations in these companies. Lack of understanding of lean manufacturing concepts could also be another reason for the low rate of implementation.

Table 4.11 Responses on 5S practices

5S practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	26.9	43.6	21.8	7.7	100.0
Public owned	0.0	16.3	21.6	37.8	24.3	100.0
Private owned	0.0	0.0	0.0	39.4	60.6	100.0

Source: Primary data

4.3.7 Production smoothing practices

Table 4.12 shows that production smoothing practices have extensively been implemented by the three categories of companies. Government owned 92.3%, public owned 83.8% and private owned 90.9% of the respondents agreed that their respective companies have adopted production smoothing practices. This is probably because of the nature of sugar production processes which are arranged according to similar product routing and processing requirements and therefore easy to adopt these practices. In sugar manufacturing, the product is a standardised product which can easily be produced on a continuous flow and thus production smoothing is applicable to a great extent.

Table 4.12 Responses on production smoothing practices

Production smoothing practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	0.0	7.7	89.7	2.6	100.0
Public owned	0.0	0.0	16.2	67.6	16.2	100.0
Private owned	0.0	0.0	9.1	81.8	9.1	100.0

Source: Primary data

4.3.8 Standardization of work practices

Table 4.13 shows that the only public owned sugar company has extensively implemented standardization of work practices (73.0%). The other companies, government (6.4%) and privately owned (15.1%) seem not to understand the concept as sugar production processes largely remain the same. Respondents in these two categories (Govt. 76.9% and Private 75.8%) of companies neither agreed nor disagreed whether these practices have been implemented in their companies or not. With the implementation of ISO in government owned sugar companies the concept of standardization of work could have been a rather obvious concept but this is not the case. The understanding of lean manufacturing concepts as a whole seems to be the reason why most of these practices are not implemented. The public owned sugar company seem to be the only sugar company benefiting from the concept of ISO going by the results obtained in table 4.13

Table 4.13 Responses on standardization of work practices

Standardization of work practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	16.7	76.9	3.8	2.6	100.0
Public owned	0.0	0.0	27.0	51.4	21.6	100.0
Private owned	0.0	9.1	75.8	12.1	3.0	100.0

Source: Primary data

4.3.9 Total productive maintenance practices

Total productive maintenance is an initiative for optimizing the reliability and effectiveness of manufacturing equipment. Table 4.14 shows that 84.8% of the respondents in the only public owned sugar company agreed that their company had adopted total productive maintenance practices followed by the privately owned with 54.4% of the respondents agreeing that total productive maintenance practices had been adopted. It is evident from the results that government owned sugar companies have not even attempted to adopt these practices with 85.4% agreeing that these practices have not been adopted. Government owned companies seem to be using the traditional maintenance practices where the plant is put on shut down for months to allow for maintenance. Bureaucracies in procurement of spare parts especially in government enterprises and lack of intellectual capital as evidenced by the number of older employees in government owned companies who have worked for over ten years might be the reasons for the low implementation of total productive maintenance practices.

Table 4.14 Responses on total productive maintenance practices

Total productive maintenance practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	9.1	76.3	7.7	6.9	0.0	100.0
Public owned	0.0	0.0	15.2	69.6	15.2	100.0
Private owned	2.6	39.4	3.6	45.3	9.1	100.0

Source: Primary data

4.3.10 Value stream mapping practices

Value stream mapping is a technique that has a very wide acceptance in the sugar sector as the results reveal. Table 4.15 shows that Government owned sugar companies 81.2%, public owned 83.8% and private owned 78.7% of the respondents agreed that value stream mapping practices have been adopted in their firms. They agreed that wastes that occur in the process of producing sugar are identified and opportunities for process improvement are easily identified. This could be because of the nature of sugar production processes which are arranged according to similar product routing and processing requirements and therefore easy to adopt these practices. It is easy to identify wastes when the flow of materials and information needed to transit goods to the end customer is identified and documented.

Table 4.15 Responses on value stream mapping practices

Value stream mapping practices		Extent of implementation Percentage response				
	Not at all	Not always	Neutral	To some extent	To a great extent	Total
Government owned	0.0	2.5	16.3	78.7	2.5	100.0
Public owned	0.0	0.0	16.2	64.9	18.9	100.0
Private owned	6.1	9.1	6.1	75.7	3.0	100.0

Source: Primary data

4.3.11 Total quality management practices

Total quality management is both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. The low rate of implementation of total quality management in privately owned sugar companies with only 6.1% (Table 4.16) of the respondents agreeing that such practices have been adopted can be explained by the fact that these companies have also not attempted to implement ISO systems. Organizational culture and lack of top management commitment in the privately owned sugar companies and a very low rate of employee involvement in the business processes could be reasons for a low rate of implementation of total quality management practices. Government owned companies are ISO certified but the implementation of total quality management practices are low at 52.5% as opposed to public companies at 67.5%. The government owned sugar companies seem to have implemented ISO standard in isolation without integrating the practices with other best practices and techniques like standardization of work where again the government owned sugar companies have scored very low (6.4% table 4.13) in terms of implementation.

Table 4.16 Responses on total quality management practices

		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	0.0	47.5	50.0	2.5	100.0
Public owned	0.0	10.8	21.7	48.6	18.9	100.0
Private owned	0.0	69.7	24.2	6.1	0.0	100.0

Source: Primary data

4.3.12 Visual display and control practices

Visual display and control enables anyone to more easily understand what is going on in the shop floor and also indicates safety lines and location for every tool. Table 4.17 shows that respondents from the government owned sugar companies seem not to be aware of the practice and remained non committal (48.7%) while 51.3% of the respondents in the public companies agreed that such practices have been implemented in their organization. Visual display and control practices seem to have been implemented by the private sugar companies to a great extent with 69.7% of the respondents agreeing to have implemented the practices. These visual displays and controls provide workers with clear and concise communication and a guide through the process. This to a larger extent improves ergonomics and employee safety. Privately owned sugar companies in

Kenya are family businesses and to a larger extent foreign owned. The investors want to abide by the law and avoid the negative publicity that a company attracts when found not abiding by the laws of the land. This might be the reason why privately owned sugar companies have to a greater extent implemented visual display and control practices than government (28.8%) and public sugar companies (51.3%).

Table 4.17 Responses on visual display and control practices

Visual display and control practices		Extent of implementation Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	22.5	48.7	28.8	0.0	100.0
Public owned	5.4	10.8	32.5	40.5	10.8	100.0
Private owned	0.0	24.2	6.1	63.6	6.1	100.0

Source: Primary data

4.4 Summary of results for lean implementation

Table 4.18 below gives a summary of results for implementation of lean manufacturing practices. The summary gives the mean, standard deviation, variance and percentages for responses received. The summary results gives the overall implementation of lean manufacturing practices in the sugar sector in Kenya, giving the most adopted tool and technique as revealed by the mean score.

The results show that lean manufacturing practices adopted by the sugar industries are those associated with customer involvement (mean 3.97), production smoothing (mean

3.97), value stream mapping (mean 3.82), visual display and control (mean 3.75), Kanban (mean 3.69), and 5S (mean 3.59).

Customer involvement practices top the list of most implemented practices in the sugar industries. This shows that the sugar companies are in close contact with their customers and the customers give feedback on quality and delivery performance. There is also exchange of product development and marketing information with their customers. It is also noted that sugar as a product is not sold directly to consumers by the sugar companies but through distributors and this explains why there is a very close interaction between the companies and the customers who happens to be distributors. The sugar companies also maintain a close relationship for purposes of getting market intelligence and for gaining competitive advantage over competitors.

Production smoothing practices also rank highly as the most implemented lean manufacturing practice. This is probably because of sugar production processes which are universal in nature where production equipment is arranged according to product routing and processing requirements and therefore easy to adopt. In sugar manufacturing, the product is a standardised product which can easily be produced on a continuous flow and thus production smoothing practices are applicable to a great extent.

Value stream mapping practices have also been implemented by the sugar companies to a great extent. This could be because of the nature of sugar production processes which are arranged according to similar product routing and processing requirements and therefore easy to adopt these practices as described above. It is easy to identify wastes when the flow of materials and information needed to transit goods to the end customer are identified and documented and this is what value stream mapping is all about.

Visual display and control practices have greatly been implemented in the sugar industry and more intensely in the private sugar industries. These visual displays and controls provide workers with clear and concise communication and a guide through the process and to a larger extent improve ergonomics and employee safety.

Kanban practices have also gained popularity in the sugar sector though to a lesser extent as compared to other practices already discussed. Kanban is a simple execution tool rather than a planning tool. Kanban is a basic practice involving a signalling card which has information about amount of products to be produced, origin of the product, and destination of the product and can be implemented at any level. It has been implemented by the sugar industry due to its simplicity and requires little resources.

5S practices have been implemented to a reasonably good extent though more substantially in privately owned sugar companies. 5S is also associated with employee safety and ergonomics. 5S involves removing and designating tools, materials and equipment to specific and known positions leaving only necessary ones for use. It also involves clearly labelling and systematically arranging items for the easiest and most efficient access in order to promote efficient work flow. This includes; most frequently used tools and equipment is located close to the user, tools and tools drawers are arranged visibly to open and close with less motion, work instructions are regularly updated and ergonomics guidelines used in work and tool design. Implementation of 5S practices helps handle problems of hidden safety hazards and unreasonable ergonomics which any manufacturing operation should be keen to address.

The sugar sector in Kenya has not implemented very important tools and techniques like standardization of work (mean 3.22) and total productive maintenance (mean 2.91). It is interesting to note that 62.5% (table 4.5) of the sugar companies are ISO certified but have actually not implemented practices and activities associated with total quality management. Total quality management practices and activities have a mean of 3.34 as given in table 4.18. It is also interesting to also note that supplier involvement and just in time practices (mean 2.91) and adoption of new technology (mean 2.65) are practices that have been adopted by the sugar companies to a lesser extent.

There are employees who have been in the sugar industry especially government owned for over thirty years and have no new knowledge to offer to their companies. The sugar sector in Kenya is an old industry spanning over a decade now considering that industrial sugar cane farming was introduced in Kenya in 1902 and the first sugar industry was set up in Miwani in 1922. Machinery being used in some of the sugar companies is old and using ancient technology therefore cannot be modernised unless the old equipment are done away with and new ones installed of modern technology. It is therefore difficult to adopt new technology when old machinery is still in place.

Table 4.18 Summary of results of lean manufacturing practices

Variable	Mean	Std D	Variance	Not at all %	Not always %	Neutral %	To some extent %	To a great extent %
Employee involvement practices	3.31	0.935	0.874	4.0	18.0	23.3	52.0	2.7
Supplier involvement and JIT practices	2.91	0.530	0.281	0.7	15.3	77.3	5.4	1.3
Customer involvement practices	3.97	0.680	0.462	0.0	3.3	14.7	64.0	18.0
Adoption of new technology	2.65	1.210	1.463	15.3	44.0	6.7	28.0	6.0
Kanban practices	3.69	0.625	0.391	0.0	4.0	28.0	63.3	4.7
5S practices	3.59	1.043	1.087	0.0	18.2	28.4	29.8	23.6
Production smoothing	3.97	0.420	0.176	0.0	0.0	10.1	82.5	7.4
Standardisation of work practices	3.22	0.733	0.538	0.0	10.8	64.2	17.6	7.4
Total productive maintenance	2.91	1.100	1.21	2.0	50.0	11.5	27.7	8.8
Value stream mapping practices	3.82	0.656	0.43	1.3	3.3	14.0	74.7	6.7
Total quality management	3.34	0.842	0.709	0.0	18.0	36.0	40.0	6.0
Visual display and control practices	3.75	0.867	0.751	1.3	20.0	35.3	39.4	4.0

Source: Primary data

4.5 Factory time efficiency

Part C of the questionnaire asked respondents whether implementation of lean manufacturing practices and activities had impacted on factory time efficiency.

4.5.1 Percentage responses by company ownership

Factory time efficiency is the index that measures the ability of a factory to sustain operations throughout the year without interruptions and is an important pointer to operational performance of a manufacturing industry. Table 4.19 shows that respondents in the government owned sugar companies (52.5%) agreed that implementation of lean manufacturing practices and activities had actually improved factory time efficiency while 47.5% could not say with certainty whether lean practices had improved factory time efficiency. The same case goes to respondents in the public owned sugar companies where 62.2% were certain that implementation of lean practices and activities had improved factory time efficiency while 37.8% were not certain. 78.8% of the respondents in the privately owned sugar companies were uncertain while only 18.2% were certain that implementation of lean practices and activities had impacted positively on factory time efficiency. For government and privately owned sugar companies the levels of uncertainty were high as to whether implementation of lean practices in manufacturing had improved management of factory time. It is evident from the results obtained that there are no measures of performance improvement in the two categories of sugar companies and it was difficult for respondents to really quantify any improvement associated with implementation of lean manufacturing practices.

Table 4.19 Responses on impact of lean implementation on factory time efficiency

Factory time efficiency		Percentage response				Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Government owned	0.0	0.0	47.5	52.5	0.0	100.0
Public owned	0.0	0.0	37.8	62.2	0.0	100.0
Private owned	0.0	3.0	78.8	18.2	0.0	100.0

Source: Primary data

4.5.2 Regression models for lean manufacturing practices in relation to factory time efficiency

Regression analysis was conducted using data collected from the eight sugar manufacturing companies. The adjusted R^2 value (0.241) in table 4.20 indicates that overall there is a positive relationship between lean manufacturing practices and factory time efficiency. The results of ANOVA show that this relationship is significant (Table 4.21)

Table 4.20 Relationship between lean manufacturing practices and factory time efficiency

R	R^2	Adjusted R^2	Std error of the estimate
0.491	0.241	0.174	0.46667

Source: Primary data

Table 4.21 Results of ANOVA relating to factory time efficiency

	Sum of Squares	df	Mean Square	F	Sig.
Regression	9.356	12	0.780	3.580	0.000
Residual	29.400	135	0.218		
Total	38.757	147			

Source: Primary data

4.5.2.1 Relationship between lean manufacturing practices and factory time efficiency for government owned sugar companies

Table 4.22 indicate that for government owned sugar companies customer involvement and kanban practices have a significant impact on factory time efficiency.

Table 4.22 Relationship between lean manufacturing practices and factory time efficiency for government owned sugar companies

	Un-standardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
Variables	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	2.907	1.023		2.843	.006	.865	4.949
Employee involvement	.095	.103	.112	.919	.362	-.111	.300
Supplier &JIT practices	-.003	.130	-.004	-.026	.979	-.263	.256
Customer involvement	.254	.127	.265	2.006	.049	.001	.507
New technology	.019	.131	.025	.147	.883	-.242	.281
Kanban practices	-.391	.132	-.368	-2.969	.004	-.653	-.128
5s practices	-.022	.105	-.040	-.212	.833	-.233	.188
Prod. smoothing practices	-.136	.217	-.086	-.629	.532	-.570	.297
Standardization of works practices	.144	.144	.158	1.001	.320	-.143	.431
TPM practices	.210	.155	.255	1.360	.179	-.098	.519
VSM practices	.185	.182	.154	1.013	.315	-.180	.549
TQM practices	.061	.134	.066	.450	.654	-.208	.329
Visual display and control practices	-.173	.139	-.250	-1.246	.217	-.451	.104

Source: Primary data

4.5.2.2 Relationship between lean manufacturing practices and factory time efficiency for public owned sugar companies

Table 4.23 indicate that for public owned sugar companies customer involvement practices and value stream mapping practices have significant impact on factory time efficiency.

Table 4.23 Relationship between lean manufacturing practices and factory time efficiency for public owned sugar companies

	Un-standardized Coefficients		Standardize Coefficients	t	Sig.	95% Confidence Interval for B	
Variables	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	2.456	1.542		1.593	.124	-.727	5.638
Employee involvement	-.052	.247	-.089	-.209	.836	-.563	.459
Supplier &JIT practices	.083	.220	.080	.379	.708	-.371	.537
Customer involvement	.299	.126	.465	2.363	.027	.038	.560
New technology	.132	.183	.162	.720	.478	-.246	.510
Kanban practices	.215	.138	.301	1.558	.132	-.070	.499
5s practices	.106	.121	.220	.874	.391	-.144	.356
Production smoothing practices	-.545	.330	-.640	-1.649	.112	-1.226	.137
Stand. of works practices	.226	.240	.324	.944	.355	-.268	.721
TPM practices	.064	.149	.096	.429	.672	-.244	.372
VSM practices	-.569	.213	-.695	-2.676	.013	-1.009	-.130
TQM practices	.426	.280	.774	1.521	.141	-.152	1.003
Visual display and control practices	.037	.123	.077	.305	.763	-.216	.291

Source: Primary data

4.5.2.3 Relationship between lean manufacturing practices and factory time efficiency for privately owned sugar companies

Table 4.24 indicate that for privately owned sugar companies; supplier involvement and JIT practices, adoption of new technology and visual display and control practices have significant impact on factory time efficiency.

Table 4.24 Relationship between lean manufacturing practices and factory time efficiency for privately owned sugar companies

	Un-standardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
Variables	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	.645	1.736		.372	.714	-2.976	4.267
Employee involvement	-.074	.159	-.149	-.467	.646	-.407	.258
Supplier involvement and JIT practices	.475	.247	.601	1.924	.069	-.040	.990
Customer involvement	.059	.147	.082	.403	.691	-.248	.366
New technology	-.374	.167	-1.140	-2.237	.037	-.723	-.025
Kanban practices	.062	.170	.116	.366	.719	-.292	.417
5s practices	-.161	.169	-.181	-.957	.350	-.514	.191
Prod. Smoothing	.303	.283	.297	1.069	.298	-.288	.894
Standardisation of works practices	-.203	.225	-.266	-.902	.378	-.673	.267
TPM practices	.085	.206	.181	.415	.683	-.344	.515
VSM practices	.195	.177	.412	1.104	.283	-.174	.564
TQM practices	-.038	.171	-.052	-.223	.826	-.394	.318
Visual display and control practices	.345	.181	.733	1.901	.072	-.034	.723

Source: Primary data

4.6 Challenges of implementation of lean manufacturing

The last part of the questionnaire asked the respondents to indicate obstacles they have faced while implementing lean from a given list of obstacles related to lean implementation.

Table 4.25 gives percentage responses by company ownership, mean, standard deviation and variance. The respondents cited lack of understanding of lean manufacturing concepts (mean 4.15), the nature of manufacturing processes and facilities (mean 4.07), organizational culture (mean 3.66) and lack of intellectual capital (mean 3.60) as the major obstacles of implementing lean manufacturing in their companies.

High volume, low variety products and inflexible processes characterize the sugar manufacturing environment. Managers have been slow to adapt the ideas of lean into these processes and the fear comes from inflexibility of the process where it is more difficult to reduce lot size. For example, in the continuous process industry like in sugar production , set up times are typically long and it is costly to shutdown the process for a changeover and these could be some of the reasons why such challenges were cited by respondents in the sugar companies surveyed.

Organizational culture was also cited as an obstacle in lean implementation more so in public and private sugar companies. This could be because of the management systems that these sugar industries have adopted. These two categories of sugar companies seem to have strong management control which has made the organization structure bureaucratic and subsequently making it difficult to change from the existing ways of doing things and therefore an obstacle in lean implementation. Government owned companies have employees who have worked for over ten years (Table 4.26 below 32.5%) and are likely to resist change while the private owned companies are family businesses with no employee involvement at all. These factors might have contributed to this obstacle.

Lack of intellectual capital was cited as an obstacle of lean implementation in the sugar companies. For government owned companies, this is probably because of the high number of employees who have over ten years working life with these companies (Table 4.26 below 32.5%) and have not acquired new knowledge for the time they were employed. There are more old employees now who do not have relevant skills required in the sector to make it competitive. For the privately owned sugar companies this could be because of the nature of organizational and management structures adopted and considering that these are family businesses and largely foreign owned, intellectual capacity might not be a consideration for employment. Lack of time for implementation of lean practices, lack of top management support, failure of past lean projects and lack of communication from top management ranked the least in that order. The respondents could not point out a failed lean project in their companies may be because they lacked understanding of lean manufacturing concepts and did not know that even some of the failed projects could actually be classified as lean projects. Lack of understanding of lean manufacturing concepts was given as a number one obstacle.

Table 4.25 Challenges of implementation of lean manufacturing practices

	Percentage responses			Mean	Std D	Var.
	Govt. owned	Public owned	Private owned			
Lack of top management support	0.0	10.8	21.2	2.11	0.770	0.593
Failure of past lean projects	1.3	27.0	3.0	2.11	0.824	0.678
Inability to quantify benefits	65.0	37.8	63.7	3.50	1.236	1.527
Lack of time to implement	12.5	59.4	3.0	1.85	0.918	0.842
Lack of intellectual capital	92.6	16.2	84.9	3.60	1.176	1.383
Company/ organizational culture	80.0	54.0	84.9	3.66	0.784	0.615
Budget constraints	26.3	56.8	42.4	3.04	1.055	1.112
Employee resistance	0.0	37.8	3.0	2.77	0.718	0.512
Backsliding to the old ways of working	7.5	56.7	3.1	2.79	0.880	0.774
Lack of communication from top mgnt	10.0	10.8	30.4	2.63	0.958	0.918
Lack of understanding of lean concepts	97.5	54.0	90.9	4.15	0.831	0.690
The nature of manufacturing processes and facilities	92.8	27.0	96.9	4.07	0.932	0.868

Source: Primary data

Table 4.26 Experience of respondents by company ownership

	Percentage responses				Total
	< 2 years	2 to 5yrs	6 to 10yrs	> 10 yrs	
Government owned	3.75	7.5	56.25	32.5	100.0
Public owned	24.4	0	37.8	37.8	100.0
Private owned	6.0	48.5	27.3	18.2	100.0

Source: Primary data

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of findings

The purpose of this research project was to examine the extent to which lean manufacturing tools and techniques are implemented by sugar manufacturing companies in Kenya, their impact on the firms' time efficiency and obstacles faced by the companies while implementing lean.

The results show that customer involvement, production smoothing, value stream mapping, visual display and control, kanban and 5S are lean manufacturing tools and techniques that have been implemented by the three categories of sugar companies to some extent though not in a systematic manner.

Customer involvement and kanban practices have a significant impact on factory time efficiency in government owned sugar companies while supplier involvement and just in time practices, adoption of new technology and visual display and controls have a significant impact on factory time efficiency in privately owned sugar companies. On the other hand, customer involvement practices and value stream mapping have a significant impact on factory time efficiency in public owned sugar companies.

The sugar sector has had a number of challenges in the process of implementing lean. The findings indicated that lack of understanding of lean manufacturing concepts, organizational culture and the nature of manufacturing processes and facilities as the major obstacles of implementing lean manufacturing in the sugar companies.

5.2 Conclusion

This research project has provided important insights into the current status of lean manufacturing implementation in the sugar sector in Kenya, the effect of lean implementation on factory time efficiency as well as highlighted some of the obstacles faced by the sector in the process of implementing lean.

The companies were found to have implemented lean manufacturing practices for different reasons. Privately owned sugar companies have concentrated more on visual display and control and 5S practices as a way of addressing safety and ergonomic issues. These practices to a larger extent improve ergonomics and employee safety. Government owned companies have implemented more of waste management practices like value stream mapping and production smoothing. On the other hand, public owned companies have concentrated more on practices that address delivery on time like total productive maintenance and adoption of new technology.

There is lack of a general understanding of lean manufacturing practices and the sugar companies have not employed a systematic approach in their implementation. Companies have implemented these practices in isolation and have therefore not reaped the full benefits of lean. According to Herron and Braident (2007) and Bhasin and Burcher (2006), lean tools should not be implemented in isolation; they were developed for a reason, which was to support an overall strategy. They have also suggested that it was better to embrace more lean tools rather than practicing one or two isolated ones.

Overall, it is shown that the respondent companies are “low to moderate” adopters of lean manufacturing and the degree of implementation has varied significantly among the three categories of companies; government, public and private. In addition, regression analysis shows that few lean practices have significant impact on factory time efficiency dependent on the extent of implementation of the practice. It is hoped that the information accrued from this research project will trigger more studies to be conducted in lean manufacturing not only in the sugar sector but other areas of the Kenyan economy.

5.3 Recommendations

Based on the analysis and conclusions of this research project, a number of recommendations for the sugar sector are proposed;

- Companies in the sugar sector in Kenya need to give attention to the implementation of all the key areas of lean manufacturing practices from a holistic perspective in order to reap the full benefits of lean and significantly improve their operational performance; more specifically factory time efficiency.
- Sugar companies are advised to consider implementing basic practices like 5S, visual display and control, employee involvement and standardization of work practices before implementing advanced practices like value stream mapping and production smoothing. Production smoothing cannot be implemented for example in an environment of poor quality, unstable machine conditions and poor housekeeping.
- Implementation of lean manufacturing practices should support the company business strategy. The implementation should be in line with the corporate vision, mission, values and plans including communication and evaluation plans to build employee buy-in and communicate results. This will ensure that performance is

measured to track actual performance against expectations, new initiatives, budgets including resources needed for new initiatives and current operations for lean projects.

- Sugar companies are currently implementing lean in a piecemeal approach instead of a holistic manner. This piecemeal approach is as a result of lack of understanding of lean manufacturing concepts and principles. A focused training approach is recommended for a better understanding among personnel of the key principles of waste elimination and flow of value.
- Outcomes for lean practices need to be determined and should be business driven. Questions need to be asked whether implementation of lean projects supports core beliefs, market opportunities, competition, financial position, short and long term goals and an understanding of what satisfies the customer. Effectiveness of lean practices needs to be evaluated. Effectiveness should be measured through performance measurements such as inventory, cycle time, product quality and delivery time.
- The sugar sector in Kenya needs to deliberately seek to develop mutually- focused relationships with external stakeholders like local universities, equipment manufacturers and technology providers, internationally recognised sugar producers for benchmarking purposes and capacity enhancement institutions specifically those in areas of process improvement and operational excellence like KIRDI for purposes of developing capacity in the sector.

5.4 Limitations of the study

There are some limitations to this research project. Several practices and activities were selected associated with lean manufacturing and not specific to the sugar sector in Kenya. However, there may be other practices and activities that can be related to lean manufacturing and more relevant to the sugar sector that were not included in the study. The study collected information from the operations divisions of all the sugar companies in Kenya including only respondents from production, engineering and quality assurance. Some aspects of the study could probably have been handled by respondents from other departments and not only departments in operations division.

5.5 Suggestions for further research

The continued managerial popularity of lean manufacturing practices is sufficient justification for continued investigation of the phenomena and the above conclusions suggest a number of potential areas for further investigation.

Further research is required not only in the sugar sector but also in other sectors of the economy to provide more evidence on the actual competitive impact of lean implementation in the manufacturing industries in Kenya. Information is required on how lean manufacturing concept can be used as an overall competitive position of a firm. The Kenyan sugar industry lacks information on lean concepts despite enormous challenges in areas such as maintenance which can easily be managed through lean implementation. Further research is also needed on how value stream mapping as a technique can be used to minimize wastes in the sector so as to lower the cost of sugar production in Kenya. On a general level, there is need for replication studies, and therefore, more studies in the sugar sector are suggested.

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APPENDICES

Appendix A: Survey questionnaire

Your help is needed on this important research. The purpose of the research project is to examine the extent to which lean manufacturing tools and techniques have been adopted by the eight sugar manufacturing industries in Kenya and their effects to factory time efficiency. The survey questions will cover a number of different lean manufacturing tools and techniques and will also ask you to give responses on the effect of the adopted lean tools and techniques in your organizations factory time efficiency. This information will help the researcher understand the extent of adoption of these lean tools and techniques in your organization and their effects on factory time efficiency.

This research project is strictly for academic purposes and no disclosures will be made in respect of the respondents. A copy of the final research project will be made available to your organization on request.

Participation in this research is voluntary. If you wish to participate, please answer the questions on the next 5 pages (pages 2 - 6). Please try to answer all questions in this questionnaire.

Thank you for your help in this important research.

Instructions to fill the questionnaire:

1. **READ** carefully the following questionnaire.
2. The questionnaire has four parts; **A** – Company profile; **B –** Questions on lean manufacturing practices/ activities; **C** – Factory time management; **D** – Challenges of lean implementation
3. There are 2 kinds of questions:

   a. Questions where the answer is a short sentence.

   b. Questions where you have to **tick** the appropriate box.

Part A: Company profile

Please **tick** the appropriate box describing your company:

1. Total number of employees

   ☐ Less than 800 employees

   ☐ More than 801 employees

2. How long have you been working in this company?

   ☐ Less than two years

   ☐ Two to five years

   ☐ Five to ten years

   ☐ More than ten years.

3. Indicate ownership type of your company

   ☐ Government owned

   ☐ Public owned

   ☐ Private owned

   Others specify ______________________________

4. Has your company been certified by one or more of the following ISO standards? Please tick more than one box if appropriate.

   ☐ ISO 14001: 2005 Environmental Management System

   ☐ ISO 9001: 2008 Quality Management System

   ☐ ISO 22001: 2005 Food Safety Management System

   Others specify ______________________________

Part B: Lean manufacturing practices/ activities

To what extent (in a scale of 1-5) the following practices/activities are implemented in your company? Please **tick** the response which best describes your opinion.

Key

1: Not at all 2: Not always 3: Neutral 4: To some extent 5: To a great extent

1.	Problem solving teams are made up of shop-floor employees	1	2	3	4	5
2.	Shop-floor employees lead product/process improvement efforts	1	2	3	4	5
3.	Shop-floor employees undergo cross-functional training	1	2	3	4	5
4.	Shop-floor employees drive suggestion programs	1	2	3	4	5
5.	Shop –floor employees are appraised on production output	1	2	3	4	5
6.	We frequently are in close contact with our suppliers	1	2	3	4	5
7.	We give our suppliers feedback on quality and delivery performance	1	2	3	4	5
8.	We strive to establish long-term relationship with our suppliers	1	2	3	4	5
9.	Suppliers are directly involved in the new product development process	1	2	3	4	5
10.	Our key suppliers deliver to our plant on just in time (JIT) basis	1	2	3	4	5
11.	Our suppliers are located near our plant	1	2	3	4	5
12.	Our suppliers are involved in material requirement planning	1	2	3	4	5
13.	We frequently are in close contact with our customers	1	2	3	4	5
14.	Our customers seldom visit our plants	1	2	3	4	5
15.	Our customers give us feedback on quality and delivery performance	1	2	3	4	5
16.	Our customers are actively involved in current and future product offerings	1	2	3	4	5
17.	Use of modern machines and processes has helped us lower production costs	1	2	3	4	5
18.	We use automatic monitoring devices in our processes	1	2	3	4	5
19.	Full-proof systems provide signals for preventing errors or mistakes in our processes	1	2	3	4	5
20.	Potential failure of a product or process are easily recognised	1	2	3	4	5
21.	Process parameters are displayed on digital screens	1	2	3	4	5
22.	Very few people are employed to monitor the process	1	2	3	4	5
23.	Our process start-ups and shutdowns are uniform	1	2	3	4	5
24.	Production at stations is "pulled" by the current demand of the next station	1	2	3	4	5

25.	Production is "pulled" by the shipment of finished goods	1	2	3	4	5
26.	Products are produced to replace those consumed by customers	1	2	3	4	5
27.	Only materials to be used are available near the production line	1	2	3	4	5
28.	We use Kanban, squares, or containers of signals for production control	1	2	3	4	5
29.	Necessary items are sorted from those that are unnecessary	1	2	3	4	5
30.	Discharge area of unwanted materials is defined	1	2	3	4	5
31.	Unwanted items are moved to discharge area	1	2	3	4	5
32.	Items are arranged to permit easy access to materials and tools	1	2	3	4	5
33.	Proper position of tools, materials and objects are identified	1	2	3	4	5
34.	Materials or objects are always in their designated places	1	2	3	4	5
35.	Rolls, tools, jigs and fixtures are well maintained and clean	1	2	3	4	5
36.	Actions have been developed to remove sources of wastes	1	2	3	4	5
37.	Products are classified into groups with similar processing requirements	1	2	3	4	5
38.	Products are classified into groups with similar routing requirements	1	2	3	4	5
39.	Equipment is grouped to produce a continuous flow of families of products	1	2	3	4	5
40.	Mostly standardized/made-to-order products are produced	1	2	3	4	5
41.	Production levels are constant from day to day	1	2	3	4	5
42.	Production workers know quantities of demanded products in a day	1	2	3	4	5
43.	Workers know available production time in a day	1	2	3	4	5
44.	Workers are multi-skilled	1	2	3	4	5
45.	Pace of production is directly linked with rate of customer demand	1	2	3	4	5
46.	Every worker follows the same processing steps at all time	1	2	3	4	5
47.	Standards for work are set and followed	1	2	3	4	5
48.	We dedicate a portion of everyday to planned equipment maintenance related activities	1	2	3	4	5
49.	Basic quantifiable policies and goals on maintenance are established	1	2	3	4	5
50.	We maintain all our equipment regularly	1	2	3	4	5
51.	Improvement effectiveness of each piece of equipment is known	1	2	3	4	5
52.	We maintain excellent records of all equipment maintenance activities	1	2	3	4	5
53.	We post equipment maintenance records on shop floor for active sharing with employees	1	2	3	4	5
54.	The flow of materials and information needed to transit goods to end	1	2	3	4	5

	customer is identified and document					
55.	Processes used to produce and ship products, both value-adding and non-value adding (waste) are identified	1	2	3	4	5
56.	Manufacturing wastes that occur in the process can easily be identified	1	2	3	4	5
57.	Processing time for each operation is known	1	2	3	4	5
58.	Opportunities for process improvement are easily identified	1	2	3	4	5
59.	Data is recorded for amount of raw materials used by each process	1	2	3	4	5
60.	Data is recorded for amount of materials that end up in the product	1	2	3	4	5
61.	A world – class manufacturing implementation road map is documented	1	2	3	4	5
62.	Internal and external customers of the organization are identified	1	2	3	4	5
63.	We regularly conduct customer satisfaction surveys	1	2	3	4	5
64.	Production systems are continuously improved for good quality through quality improvement teams	1	2	3	4	5
65.	Quality is measured through feedback from customers and workers	1	2	3	4	5
66.	We use statistical techniques extensively to reduce process variance	1	2	3	4	5
67.	We use fishbone type diagrams to identify causes of quality problems	1	2	3	4	5
68.	We conduct process capability studies before product launch	1	2	3	4	5
69.	Visual pictures guide employees through the process	1	2	3	4	5
70.	Arrows are drawn on the floor/wall to guide production flow	1	2	3	4	5
71.	Employees know what is to be inspected and how to carry out inspection through short visual presentations	1	2	3	4	5
72.	Employees know exactly where to go and what to do through visual displays	1	2	3	4	5
73.	Visual tools provide all workers with clear and concise communication	1	2	3	4	5
74.	Charts showing defect rates are used as tools on the shop floor	1	2	3	4	5
75.	Safety lines and location for every tool are easily identified at the Shop- floor	1	2	3	4	5
76.	Colour-coding and labels are used on the shop-floor	1	2	3	4	5
77.	Production real-time line performance to goals is displayed on boards	1	2	3	4	5
78.	Target production quantity compared to actual is displayed on boards	1	2	3	4	5

Part C: Factory time management

Indicate the level of your company's factory time management described by the items below.

Key

1: Not at all 2: Not always 3: Neutral 4: To some extent 5: To a great extent

1.	Process operators know when a machine is defective	1	2	3	4	5
2.	Process operators know the next production step during production operations	1	2	3	4	5
3.	Quality of raw materials, in-process and final products is easily determined	1	2	3	4	5
4.	Rated hourly machine output is easily determined	1	2	3	4	5
5.	Machine set-up and process time is known to process operators	1	2	3	4	5
6.	There is a lot of movement of tools and process materials to point of use	1	2	3	4	5
7.	Raw materials delays are experienced during production runs	1	2	3	4	5
8.	Most of our production time is taken up by rework of defective products	1	2	3	4	5
9.	The number of skilled engineers/technicians in the plant is sufficient	1	2	3	4	5
10.	Machine spare parts are always available	1	2	3	4	5
11.	Failure of control and measuring devices and equipment are rampant in our factory	1	2	3	4	5
	Others specify					
12.		1	2	3	4	5
13.		1	2	3	4	5

Part D: Challenges of lean implementation

The following have been our biggest obstacle(s) that we have faced while implementing lean in our organization;

Key

1: Not at all 2: Not always 3: Neutral 4: To some extent 5: To a great extent

1.	Lack of top management support	1	2	3	4	5
2.	Failure of past lean projects	1	2	3	4	5
3.	Inability to quantify benefits	1	2	3	4	5
4.	Lack of time to implement	1	2	3	4	5
5.	Lack of intellectual capital	1	2	3	4	5
6.	Company/ organizational culture	1	2	3	4	5
7.	Budget constraints	1	2	3	4	5
8.	Employee resistance	1	2	3	4	5
9.	Backsliding to the old ways of working	1	2	3	4	5
10.	Lack of communication from top management	1	2	3	4	5
11.	Lack of understanding of lean manufacturing concepts	1	2	3	4	5
12.	The nature of manufacturing processes and facilities	1	2	3	4	5