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

Gerald Ochieng Ondiek and Stephen Mgenyi Kisombe

University of Nairobi, School of business,

gondiek@uonbi.ac.ke; xombe70@yahoo.com

ABSTRACT

The study sought to examine the extent to which lean manufacturing tools and techniques are adopted by sugar processing companies in Kenya and their impact on factory time efficiency. The study was a survey covering five sugar processing companies who approved the study and those that have been in operation for more than three years. Purposive sampling was used to select a sample of 135 employees from production, engineering and quality assurance departments. Data was collected using a structured questionnaire consisting mainly of closed-ended questions and was analysed using descriptive and inferential statistics. The motivation of the study was based on the contribution of the sugar sector to the Kenyan economy.

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. The industry has only adopted practices related to lean manufacturing and there was little impact of these practices to factory time efficiency. Conclusions drawn from the research was that sugar processing 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 to enable better understanding of lean manufacturing concepts among personnel and then give attention to the implementation of all areas of lean manufacturing from a holistic perspective for the industry to reap full benefits. The research has provided insights into the implementation of lean practices in a Kenyan context using survey data as opposed to case studies.

Several practices and activities were selected associated with lean manufacturing and not specific to the sugar industry in Kenya. However, there may be other practices and activities that could 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.

Keywords: Lean manufacturing, sugar processing companies, tools and techniques, Kenyan economy**.**

INTRODUCTION

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, Huxley and Robertson (1997) lean manufacturing will be the standard manufacturing mode of the 21st century. Womack and Jones (1996) observe that 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. They note that 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. 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.

Papadopoulu & Ozbayrak (2005) observe that lean manufacturing could be a cost reduction mechanism and if well implemented it will be a guideline to world class organization. Lean manufacturing comprise of universal management principles which could be implemented anywhere and in any company as observed by 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 as noted by Pavnaskar, S.J., Gershenson, J.K. and Jambekar, A.B, (2003). Implementation of lean practices is frequently associated with improvements in operational performance measures. According to Shah and Ward (2003), 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. 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.

The Kenya sugar industry strategic plan (2010-2014) confirms that the Kenya sugar sector is a major employer and contributor to the national economy. 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 as the strategic plan continues to highlight. According to the Ministry of Agriculture (2010), 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).

In the Kenya sugar industry strategic plan it is indicated that currently, there are eight sugar factories in the country with a combined capacity to process 5 million metric tons of cane annually. However, despite these investments, self-sufficiency in sugar has remained elusive over the years as consumption continues to outstrip supply Kenya sugar research foundation, KESREF (2010) continues to highlight. 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) continues to confirm.

Ophelie (2006) notes that Kenya's sugar prices are higher than not only Brazil but also Zambia and Malawi. 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.

In 2008, KESREF scientists comprising of Wawire, N. W., Shiundu, R .M. and Mulama, P. carried out a 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 according to 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 as concluded in CGD Bills Digest (2005). None of the individual factories for example achieved their set production targets for year 2007 according to 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.

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. The researches that have been done before have majorly dealt with productivity improvement initiatives and appropriate

technologies to adopt in the sugar sector. Hence the study is set to find out the extent to which these lean manufacturing practices have been adopted in the Kenyan sugar industry and their impact on factory time efficiency.

The findings of this research paper will contribute to a great extent in the realization of Kenya Vision 2030, the sugar manufacturing sector being 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.

THEORETICAL BACKGROUND AND INFORMING LITERATURE

Lean manufacturing is defined by Smith and Hawkins (2004) 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. 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 as Womack et al, (1990) notes. Lean focuses on abolishing or reducing wastes and on maximizing or fully utilizing activities that add value from the customer's perspective. Ohno (1997) and Shingo (1997) both note that 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. 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. So the elimination of waste is the basic principle of lean manufacturing.

As described by Tiwari, A., Turner, C., and Sackett, P., (2007), there are many lean tools and techniques which help manufacturing organizations to implement lean manufacturing practices. They are interrelated in their ability to reduce cost through enhanced efficiency, which contributes to their influence on operational performance. 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 suggest 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.

Value Stream Mapping (VSM): One of the most important lean manufacturing technical methodology applied to interpret the flow of materials and information currently needed to transit goods or services to the end consumer is value stream mapping (VSM). Womack and Jones (2003) describes 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 as Rother and Shook (1999) confirms. Value stream maps serve as a critical tool that can reveal substantial opportunities to reduce costs improve production flow, save time and reduce inventory.

Just-in-time(JIT): Sugimori, Y., Kusunoki, K., and Uchikawa, S., (2008) state that just- in time (JIT) manufacturing is a lean 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. As described by Dreyfus, L.P., Ahire, S.L. and Ebrahimpour, M., (2004), the following are the requirements to produce necessary parts/ products at the necessary time ; 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 adds Ohno (1988). The performance metrics improved using JIT implementation are cost and delivery time as summarised by Huang, Rees, & Taylor III (1983).

Total Productive Maintenance (TPM): As defined by Smith and Hawkins (2004) total productive maintenance is a lean manufacturing initiative for optimizing the reliability and effectiveness of manufacturing equipment as defined by. 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 adds Tsuchiya (1992). Ravishankar, G., Burczak, C. and Vore, R.D (1992) confirms that the goal of TPM is to reduce equipment breakdowns, defects and safety problems as. 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) continues to elaborate that 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. Smith and Hawkins (2004) note that TPM requires support from top management to be effective and that it will have a major impact on failure time reduction and increases machine availability. According to Smith and Hawkins (2004), TPM dramatically improves productivity; equipment availability; quality and safety of both employees and machinery. Mckone, Schroede and Cua (2001) summarises by noting that performance metrics improved by implementing TPM are cost, quality and delivery time.

Kanban: According to Gross and Mclnnis (2003), 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. By implementing Kanbans Toyota manufacturing was able to reduce work-in-process (WIP) and the cost associated with holding inventories. Other benefits of Kanban according to 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) continues to confirm.

Production Smoothing: Abdulmalek et al (2006), describes production smoothing as a process in which the production level for each part is kept as constant as possible across and within days. 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 inventory holding costs.

5S Systems: According to Sun and Yanagawa (2006), 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 5S stands for; sort, straighten, shine, standardize and sustain according to 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 according to Chapman (2005) exacerbate the business administrative work environment and these day-to-day workplace organization issues manifest into bigger problems such as: long lead times; low productivity; high operating costs; late deliveries, unreasonable ergonomics; space constraints; frequent equipment breakdowns and hidden safety hazards.

Visual Displays and Controls: As noted by Parry and Turner (2006), 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. 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.

Standardization of Work: A very important principle of waste elimination is the standardization of worker actions as noted in Mid- America Manufacturing Technology Centre press release (2000). 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. According to Feld (2000), 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. Takt time is calculated based on the following formulae:

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

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

Conceptual model of the study

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.

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 as depicted by Ferdousi, 2009 and Achanga et al (2006). According to Achanga et al (2006) and Bamber & Dale (2000), top management is considered as a recipe to success in any new management system. In addition, the transition from traditional to lean manufacturing implementation should be driven by the top management team concludes 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 adds Keller, A.Z., Fouad, R.H. and Zaitri, C.K (1991). According to Xu and Beamon (2006), to achieve waste reduction, coordination of activities is critically important. 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 as depicted by Holden and O'Toole, 2004). To achieve these strong relationships requires an understanding of the expectation of business partners writes Hausman (2001). Participation in such relationships is recognised as contributing to firm operational performance as Frazier (1999) concludes. 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.

According to Oakland (1993), another lean manufacturing feature is the search for continuous improvement in products and processes. 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 adds 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 according to 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.

METHODOLOGY

A survey was employed by collecting data from five (Muhoroni, Chemelil, Mumias, Soin and Kibos) of the eight sugar processing companies to determine the extent to which these industries are using lean manufacturing tools and techniques in their operations. The survey excluded South Nyanza and Nzoia Sugar Companies because authorization to carry out the study was received very late after data had been collected from other sugar companies while West Kenya Sugar Company did not approve the study.

Mumias, Muhoroni, Chemelil, Kibos and Soin Sugar Companies were covered after approval was granted by the respective management to carry out the study. Butali Sugar Company was not covered in the survey because it was 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.

The study purposively selected the operations division of each of the sugar processing companies in Kenya. Each operations division in the Kenyan sugar companies' context consists of production, engineering and quality assurance departments. A total of 135 questionnaires were distributed to production, engineering and quality assurance departments of the five responding sugar processing companies and 86 were filled returning a response rate of 63.7%. Employees in production, engineering and quality assurance departments were targeted because these are the people with the most knowledge of the subject under study.

The study used primary data obtained through a structured self-administered questionnaire on employees in operations division of the five sugar processing companies. Respondents were asked to give their general characteristics and those of their organizations including experience in terms of years worked, number of people employed, ownership whether government, private or public owned and whether their operations were certified by any of the ISO standards. On a five-point likert scale 1 indicating "not at all" and 5 indicating "to a great extent" respondents were asked to indicate from a given list of lean practices/activities the extent to which lean manufacturing practices/activities were implemented in their companies and on another list of items describing factory time management practices to indicate the impact of lean practices/activities on these practices. Descriptive and inferential statistics were used to analyse data collected in the survey. Statistical Package for Social Sciences (SPSS 17.0) was used for data analysis. From the classification of the sugar industries namely; government owned, public owned and private owned, 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.

RESULTS

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.

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.

40% of the surveyed sugar companies represented large companies with employee population crossing over the 800 mark and the other 60% represented small and medium size companies with employee population below 800. The results obtained showed that 50.0% of the surveyed sugar companies were government owned and had more than 800 employees meaning that they are large companies while 50% of the surveyed sugar companies were privately owned and had less than 800 employees meaning that they are small and medium companies. The results also showed that for the surveyed sugar companies the only public owned company – Mumias Sugar Company employed more than 800 employees and therefore a large company. Among the respondents, over 75% had 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. Three sugar companies representing 60.0% of the total number of sugar companies surveyed were ISO 9001:2008 certified. Out of this figure, 20.0% were publicly owned and 40.0% were government owned. For privately owned sugar companies surveyed, 100% were not ISO certified while 100% of the government surveyed sugar companies were ISO certified.

The results in table 1 below 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).

Table 1: Summary of results of lean manufacturing practices

Variable	Mean	Std D	Var.	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 practices	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 practices	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 practices	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: *Research data*

Table 2: Results of impact of lean manufacturing practices/ activities on factory time efficiency

Company ownership	Percentage responses					Total
	Not at all	Not always	Neutral	To some extent	To a great extent	
Govt. 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: Research data

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 2 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 company (Mumias Sugar) 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.

REGRESSION MODELS FOR LEAN MANUFACTURING PRACTICES IN RELATION TO FACTORY TIME EFFICIENCY

Regression analysis was conducted using data collected from the five sugar manufacturing companies. The adjusted R^2 value (0.174) in table 3 indicates that overall there is a positive relationship between lean manufacturing practices and factory time efficiency. The results of ANOVA show that this relationship was significant (Table 4)

Table 3: 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: Research data

Table 4: Results of ANOVA relating to factory time efficiency

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

Source: Research data

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

Table 5 indicate that for government owned sugar companies customer involvement and kanban practices have a significant impact on factory time efficiency.

Table 5: 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: Research data

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

Table 6 indicate that for public owned sugar companies customer involvement practices and value stream mapping practices have significant impact on factory time efficiency.

Table 6: Relationship between lean manufacturing practices and factory time efficiency for public 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)	2.456	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: Research data

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

Table 7 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 7: 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: Research data

Summary, Discussions and Conclusions

The study sort to achieve two objectives; to examine the extent to which sugar processing companies in Kenya have implemented lean tools and techniques in their operations and; the impact of these tools and techniques on factory time efficiency.

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 processing, 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 results of the study shows that the sugar sector in Kenya has not implemented very important tools and techniques their operations like standardization of work (mean 3.22) and total productive maintenance (mean 2.91). It is interesting to note that 60.0% 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 1. 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.

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, the only public owned company- Mumias Sugar has 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 paper will trigger more studies to be conducted in lean manufacturing not only in the sugar sector but other areas of the Kenyan economy.

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.

REFERENCES

Abdulmalek, F., Rajgopal, J., and Needy. K., (2006). A Classification scheme for the process industry to guide the implementation of lean. *Engineering Management Journal, 18*(2).

Achanga, P., Shehab, E., Roy, R. and Nelder, G. (2006). Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management, 17*(4), 460-471.

Bamber, L. & Dale, B.G. (2000). Lean production: a study of application in a traditional manufacturing environment. *Production Planning and Control, 11*(3), 291-298.

Boyer, M. & Sovilla, L (2003). How to identify and remove the barriers for a successful lean implementation. *Journal of Ship Production 19* (2): 16-20.

Centre for Governance and Development Bills Digest (2005). *The trouble with the sugar industry,* Kenya

Chapman, D. (2005). Clean house with lean 5S. Quality Progress, 38(6), 27-32. Retrieved August 19, 2010, from ABI/INFORM Global. (Document ID: 854788191).

Crute, V., Ward, Y., Brown, S. & Graves, A. (2003). Implementing lean in aerospace - challenging the assumptions and understanding the challenges. *Technovation, 23*(12), 917-928.

Czabke, J., Hansen, E.N. & Doolen, T.L. (2008). A multisite field study of lean thinking in US and German secondary wood products manufacturers, *Forest Products Journal, 58*(9), 77-85.

Dreyfus, L.P., Ahire, S.L. and Ebrahimpour, M. (2004).The impact of just-in-time implementation and ISO 9000 certification on total quality management. *IEEE Transactions on Engineering Management, 51* (2), 125-41.

Feld, W. (2001). *Lean manufacturing tools, techniques, and how to use them*. St. Lucie Press, Boca Raton, FL.

Ferdousi, F. and A. Ahmed 2009. An investigation of manufacturing performance improvement through lean production: A study on Bangladeshi garment firms. *International Journal of Business and Management 4* (9): 106-114.

Freeman, C. and Perez, C. (1988). Structural crisis of adjustment: business cycles and investment behavior. In Dosi, G., Freedmand, C., Nelson, R.R., Silverberg, G. and Soete, L. (Eds), *Technical Change and Economic Theory* (pp 38- 66), Pinter, London.

Gross, J & Mclnnis, K (2003). *Kanban made simple: demystifying and applying Toyota's legendary manufacturing processes.* Amacom, New York.

Hausman, A. (2001). Variations in relationship strength and its impact on performance and satisfaction in business relationships. *The Journal of Business & IndustrialMarketing, 16* (6/7), 600-17

Herron, C. and Braident, P.M., (2007). Defining the foundation of lean manufacturing in the context of its origins (Japan). *Proceedings of the IET International Conference on Agile Manufacturing* (pp148-157). United Kingdom.

Hobbs, D. (2004). *Lean manufacturing implementation*- A complete execution manual for any size manufacturer. J. Ross Publishing.

Holden, M.T. and O'Toole, T. (2004), A quantitative exploration of communication's role in determining the governance of manufacturer-retailer relationships. *Industrial Marketing Management, 33*, 539-48.

Huang., Rees., and Taylor III., (1983). A simulation analysis of the Japanese just-in-time technique for a multiline, multistage production system. *Decision Sciences*, *14*. 326-344.

Keller, A.Z., Fouad, R.H. and Zaitri, C.K. (1991), Status and structure of just-in-time manufacturing in the UK. In Satir, A. (Ed.), *Just-in-time Manufacturing Systems* (pp.115-31), Elsevier, Amsterdam.

Kenya Sugar Board. (2009). *Kenya Sugar Board Strategic Plan 2009 to 2014*. Kenya

Kenya Sugar Research Foundation (2010). *Research Programs: Sugarcane processing program*, Kenya

Khurram and Hashmi (2006). *Introduction and Implementation of Total Quality Management(TQM)*, http://www.isixsigma.com/library/content/c031008a.asp

Kotter, J.R. (2007). Leading change -why transformation efforts fail. *Harvard business review, 85*(1), 96-104.

Lambert, D.M., Cooper, M.C. and Pagh, J.D. (1998), Supply chain management: implementation issues and research opportunities, *The International Journal of Logistics Management*, *9*(2), 1-19.

McIvor, R. (2001). Lean supply: the design and cost reduction dimensions. *European Journal of Purchasing & Supply Management, 7*, 227-42.

Mckone., Schroede., Cua., (2001). The impact of total productive maintenance practices on manufacturing performance. *Journal of operation management*, *19.*39-58.

Ministry of Agriculture. (2010). *Enhancing industry competitiveness: Kenya sugar industries strategic plan 2009 to 2014.* Kenya

Motwani, J. (2003). A business process change framework for examining lean manufacturing: a case study. *Industrial Management & Data Systems,* 103(5-6), 339-346.

Naquib, (1994).The implementation of total quality management (TQM) in a semiconductor manufacturing operation. *IEEE Transactions on semiconductor manufacturing, 6*(2) 156-162.

Oakland, J. (1993). *Total Quality Management*: The Route to Improving Performance, Butterworth-Heinemann, Oxford.

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

Ophelie, R. (2006). *Bio-fuels for transport in developing countries.* A case study of Kenya- UNEP, Nairobi- Kenya

Papadopoulu, T.C. and Ozbayrak, M. (2005). Leanness: experiences from the journey to date. *Journal of Manufacturing Technology Management, 16*(7), 784-806.

Parry, G. & Turner, C.E (2006). Application of lean visual process management tools. *Production Planning and Control, 17* (1), 77-86.

Pavnaskar, S.J., Gershenson, J.K. and Jambekar, A.B. (2003). Classification scheme for lean manufacturing tools. *International Journal Production Research, 41*(13), 3075–3090.

Ravishankar, G., Burczak, C. and Vore, R.D. (1992, June). *Competitive manufacturing through total productive maintenance*. Semiconductor Manufacturing Science Symposium. ISMSS 1992, *IEEE/SEMI International*, June 15-16, pp. 85-9.

Rineheart, J., Huxley, C., Robertson, D. (1997). *Just Another Car Factory? Lean Production and its Contents*. Cornell University Press.

Rother, M. & Shook, J. (1999). *Learning to see: Value stream mapping to create value and eliminate muda.* Lean enterprise institute: Massachusetts.

Shah, R. and Ward, P.T (2007). Defining and developing measures of lean production. *Journal of Operations Management, 25,* 785–805.

Singh, R.K., Choudhary, A.K., Tiwari, M.K., Maull, R.S., (2006a). An integrated fuzzy-based decision support system for the selection of lean tools: A case study from the steel industry. *Journal of Engineering Manufacture*, *220*, 1735-1749.

Smith, R and Hawkins, B (2004). *Lean maintenance; reduce costs, improve quality, and increase market share*. Elsevier.

Sugimori, Y., Kusunoki, K., & S. Uchikawa, S. (2008). Toyota production system and Kanban systems materialization of just-in-time and respect for human system. *International Journal of Production Research, 15*(6), 553-564.

Sun. W., & Yanagawa. T., (2006). *Implementing Lean Manufacturing Concepts in Nonmanufacturing Area;* the technology interface/Spring 2006.

Tiwari, A., Turner, C., and Sackett, P (2007). A Framework for Implementing Cost and Quality Practices within Manufacturing. *Journal of Manufacturing Technology Management, 18*(6), 731-760.

Tsuchiya, S (1992). *Quality maintenance: Zero defects through equipment management.* Productivity Press, Cambridge, MA.

van De Ven, A.H. (1986). Central problems in the management of innovation. *Management Science,32* (5), 590-607.

Wawire, N. W., Shiundu, R .M. and Mulama, P. (2008). *Sugar processing efficiency and cost reduction strategies in Kenya*. KESREF Kenya

Womack, J.P., & Jones, D.T. (1996). *Lean thinking: banish waste and create wealth in your corporation.* New York, Simon & Schuster.

Womack. J.P., Jones, D.T., Roos. D., (1990).*The machine that changed the world*. HarperCollins, New York.

Xu, L. and Beamon, B.N. (2006), Supply chain coordination and cooperation mechanisms: an attribute-based approach, *Journal of Supply Chain Management, 42* (1), 4-12.