Lean Manufacturing Implementation in Kenya

Elijah K. Mwangi.and Lucy Kamau

***Abstract*—** Many manufacturing companies are now using Lean Manufacturing (LM) as a corporate strategy to increase their global competitiveness. Lean tools such as Kaizen, 5S, Total Productive Maintenance, Kanban, Total Quality Management, Visual Stream Mapping and others are implemented as projects aimed at creating processes that give the company a competitive advantage over its competitors by reducing waste. The purpose of this study was to determine the status of lean manufacturing implementation in the Kenyan manufacturing sector. The study adopted a descriptive survey design. The target population consisted of 653 manufacturing companies that were current members of the Kenya Association of Manufacturers in 2013. Stratified sampling was applied to the sampling frame in order to achieve equitable representation of respondents from different categories of the manufacturing companies. A total of 84 respondents, one from each selected company, were selected to participate in the study. A questionnaire was sent to each respondent. A total of 37 questionnaires were returned representing a 44.0% response rate. An agglomerative hierarchical cluster analysis technique was used to uncover three lean manufacturing clusters that existed in the Kenyan manufacturing sector. Lean drivers and lean barriers were analyzed based on these lean clusters. The results showed that focus on customers is the main driving force that causes companies in the Kenyan manufacturing sector to implement lean manufacturing irrespective of their lean status. Increased flexibility and being part of the company's continuous improvement programs had the least influence on lean implementation. Lean barriers that had the greatest influence of hindering lean manufacturing implementation were lack of understanding on Lean Manufacturing concepts followed closely by cost of implementation. It was concluded that a lot of education and training on lean manufacturing and implementation is required within the Kenyan manufacturing sector.

***Keywords*—**Continuous improvement, Lean, Lean philosophy, Manufacturing, Toyota production system.

I. INTRODUCTION

CHALLENGES in today's global competition have made organizations, the world over, to seek for appropriate management strategies in order to become more efficient, productive and competitive by improving the quality of their products and services. Many firms are now using lean principles, tools and practices to improve their processes; reduce the cost of doing business; increase profitability and hence compete effectively in this highly competitive global market. Lean Manufacturing (LM) has become very popular among manufacturing companies following the success of the Toyota Motor Corporation which pioneered the Toyota Production System (TPS) which gave rise to the LM philosophy. However, it was not until the year 1990 that the LM philosophy became internationally recognized following the publication of the book titled The Machine That Changed the World by James Womack, Daniel Jones and Daniel Roos. In 1996 Womack and Jones coauthored yet another lean book titled Lean Thinking where they urged their readers to "Just-Do-It" in the spirit of Taiichi Ohno of Toyota Production System. These two books played a great role in popularizing the LM system across the world.

LM can be classified into two traditional approaches. The 'toolbox' approach and the 'lean thinking' approach [1]. The toolbox approach advocates for a more practical and project based approach that looks at lean as a collection of waste reduction tools [2], [3], [4]. On the other hand, the lean thinking approach argues that lean is more than a set of tools and advocates lean as a philosophy which focuses on delivering high quality products at the lowest price, at the right time and the total elimination of waste [2]; [5]. The lean philosophy is a fundamental way of thinking about a process, which focuses on value creation and waste elimination. Based on the principles of the TPS and Kaizen (continuous improvement) breakthrough methodology, LM aims at creating one-piece flow with Just-In-Time (JIT) management of inventory and materials. This is a complete departure from the traditional philosophies of craft and the mass production systems. It completely negates the traditional principles of production scheduling based on sales forecast and procurement based on economies of scale such as economic order quantities.

Implementing lean, however, is not always an easy undertaking. It has had its successes and failures alike. Reference [6] observed that many Chinese enterprises had deployed lean tools without appreciating the underlying lean philosophy, have unrealistic expectations of quick results on going lean, indiscriminately imitated and copied blindly how other enterprises implemented their LM, and have implemented lean based on superficial knowledge of the lean philosophy without understanding the essence of lean production. He concludes that these are some of the reasons why most of the Chinese enterprises are unsuccessful in the implementation of lean. Similarly, [7] stated that many US companies had embraced lean tools without comprehending what makes them work together in a system as they do not fully understand the power behind true TPS that lies in Toyota's continuous improvement culture. Reference [8] supports this view by observing that the success of LM implementation depends on four critical factors: leadership and management, finance, skills and expertise, and supportive organizational culture. The lean

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philosophy must be supported by everyone in the enterprise if LM is to be successfully implemented

A. Kenyan Manufacturing Sector

The Government of Kenya considers industrial production and manufacturing sector in particular a key pillar of its growth strategy and has chosen to support it over time as evidenced by various development plans and statements. Within the current blue print, Vision 2030, manufacturing is one of the pillars alongside tourism, agriculture, wholesale and retail trade, business process outsourcing and financial services. Likewise, the Big Four agenda focuses on manufacturing, agriculture, health, and housing underscoring the importance given to the manufacturing sector as an engine of growth of the Kenyan economy.

A number of empirical studies have been carried out on LM in some selected companies operating in Kenya. Reference [9] carried out a study on lean implementation in all the eight sugar factories in Kenya. He found out that sugar factories in Kenya have not given attention to all the key areas of LM. Instead a piecemeal approach is adopted which deprives the sugar factories the benefits associated with adopting LM. Reference [10] found existence of extensive adoption of World Class Manufacturing, a terminology used to refer to the Toyota Production System, processes among industrial and allied sectors and less adoption in commercial and services sectors.

In another study investigated the adoption of World Class Manufacturing in Kenya's manufacturing sector [11] found out that total quality management, focus on the customer, focus on cost control, policy of continuous improvement, reduced product cost, and reducing delivery time were rated as most important while on the other hand those that were rated less important by most of the respondents included: reducing time to market, supply chain management and optimization existing IT systems and investments. Total Quality Management was ranked highest in levels of adoption across all sectors in both studies. They also reported that firms realized cost reduction, improved product quality and reduced lead time upon adopting the practices. Furthermore, [10], [11], [12] found out that company culture, resistance to change, staff attitude, and lack of knowledge about lean posed the most challenges in the implementation process. Overall, LM was found to be in its infancy in Kenya.

II. LITERATURE REVIEW

The Lean Enterprise Institute defines lean as a set of principles, practices, and tools to create precise customer value- goods and services with higher quality and fewer defects- with less human effort, less space, less capital, and less time than the traditional systems of mass production. The basic value proposition of LM is that principles for improving workflow, decreasing setup time, eliminating waste, and conducting preventive maintenance will speed up business processes and return quick financial gains. It should be observed that continuous flow is the ultimate objective of lean production, and that creating continuous flow has been the goal of countless kaizen projects. In essence, lean emphasizes on performing only those activities that contribute something that the customer is willing to pay for, or expects in the product or service, and doing so as effectively as possible. Several authors are in agreement that LM defines the value of a product or a service from the customer point of view [1], [13], [14], [15], [16], [17]).

The key concepts of the lean philosophy is continuous improvement, waste reduction and respect for the people. Continuous improvement (Kaizen) allows employees to make mistakes in their workplaces as they try to improve the system they are working on, one step and a time. This way of thinking was introduced by the Toyota experts who stressed that the essence of successful lean thinking is building people first and then building products and a culture of challenge the status quo and practice continuous improvement [5].

Waste reduction is based on the understanding that any process that does not add value to the customer is wasteful and should be eliminated from the production flow. Only those processes that add value to the customer should be retained in the production flow [1], [5], [7], [10], [13], [17]. Tools such as Value Stream Mapping are used to identify those processes that do not add value to the customer.

LM can also be conceptualized using the configuration lens. It may be viewed as a configuration of tools/practices because the relationships among its elements are neither explicit nor precise in terms of linearity or causality. A configuration approach helps to explain how a lean system is designed from the interaction of its constituent elements taken as a whole, rather than how a lean system is designed from its constituent elements one element at a time [18]. A lean production system is an integrated manufacturing system that requires implementation of diverse set of manufacturing practices ([13]; [15]). Concurrent application of these practices should result into higher performance for the implementing organizations while reduced benefits occur where these tools and practices are implemented in isolation or in small groups [1], [8], [9], [11], [13], [15]; [17], [19], [20]. Fig 1 show some twenty eight lean tools and practices that are classified into five groups of Supplier Relationships; Customer Relationships; Human Resource Management; Manufacturing, Planning and Control; and Process and Equipment. The core thrust of LM is that these tools and practices can work synergistically to create a streamlined, high quality system that produces finished products at the pace of customer demand with little or no waste.

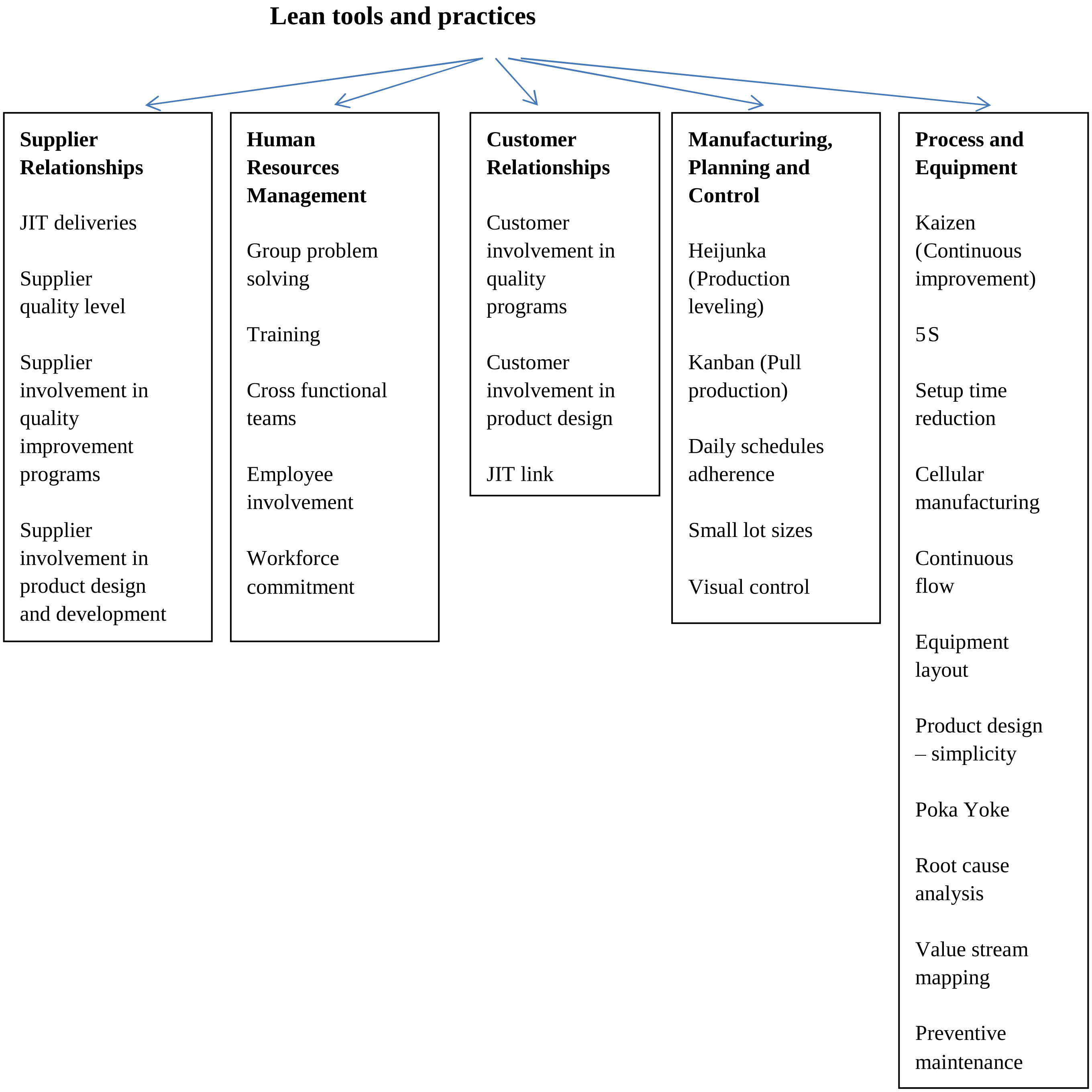

Fig 1. Lean tools and practices grouped into five categories.

A number of factors that drive organizations to choose lean manufacturing as a business strategy have been reported in only a few studies in the reviewed literature. The most frequently reported drivers are: increase market share; increase flexibility; need for survival from internal constraints; development of Key Performance Indicators; desire to employ world's best practices; part of the company's continuous improvement programs; and drive to focus on customers [11], [20]. Many studies on barriers to lean implementation have been carried out with many researchers reporting that the main problem is lack of thorough knowledge of the lean philosophy and fear of the change that come with it [6], [7], [8], [9], [20]. The two key pillars of the TPS, "continuous improvement" and "respect for the people" were also found to be important for successful lean implementation. Reference [14] found out most of the companies that fail to implement lean manufacturing successfully observe only the first pillar by undertaking Kaizen initiatives and ignore the second pillar, respect for the people, which is the most important.

Other Studies found culture, both national and company wise, as impediments to successful implementation of lean [8], [10], [14], [20]. Other reasons that appear frequently in literature include attitude of employees [11], [21]; attitude of middle level managers and lack of support from top management ([22]. Few studies reported lack of communication and cost of implementation. Some authors reported cost of implementation of lean as a major barrier to lean implementation while others singled out lack of understanding of the underlying lean concepts and philosophy [9]. Inability of the management to quantify benefits that accrue from lean implementation was also reported as a barrier to lean implementation.

Unionization status of a company, its size, its ownership and its age are other factors that are thought to influence the implementation of the lean tools and practices [8], [15], [20]. They argue that since implementing new manufacturing practices often involve changes in work organization that unions often become important partners in negotiating such work reorganization. They conclude that though there is not much research done on this area manufacturing companies with high presence of unionism are more likely not to implement lean manufacturing compared to non-unionized plants because of the resistance from their unions

A. Conceptual Framework

Lean Manufacturing approaches and procedures can be broken down to two identifiable categories: the lean philosophy and the lean manufacturing tools and practices as shown in Fig 2. The elements of the two approaches must be present for a successful lean manufacturing implementation to be realized [6], [8], [9], [20]. Interactions do exist between all the elements forming a configuration of lean tools and practices. Configurations represent non-linear synergistic effects and higher-order interactions that cannot be represented with traditional bivariate or contingency relationships [18]. Lean drivers and lean barriers are the moderating variables as they influence the strength of the relationship between the configuration of the lean tools and practices and the lean implementation.

III. METHODOLOGY

This study adopted a descriptive survey design to investigate the status of implementation of LM in the Kenyan manufacturing sector. It involved collection of primary data for analysis. According to [23], surveys are good designs for describing, explaining and exploring existing status between two or more variables at a given point in time.

The target population consisted of manufacturing companies operating in Kenya. The accessible population consisted of 653 manufacturing companies that were ordinary members of the Kenya Association of Manufacturers (KAM) in 2013. Table 3.1 shows the composition of the ordinary membership of KAM which was obtained from the Kenya Manufacturers and Exporters Directory, 2013.

Stratified sampling was applied to the sampling frame. The number of respondent companies that were sampled from each category was proportionate to the total membership of that category as shown in Table 3.1. The two main reasons for using the stratified sampling design were; to ensure that all categories were adequately represented in the sample, and to improve efficiency by gaining greater control on the composition of the sample. The sample size was calculated using the following two formulae obtained from [23].

$$n = \frac{Z^2 p(1-p)}{d^2}$$

Where n = the desired sample size if the target population is greater than 10000.

Z = the standard normal deviation at the required confidence level.

p = the proportion in the target population estimated to have characteristics being measured. d = the level of statistical significance.

If the size of the target population is less than 10000 then the required sample size, n_f, is estimated using the formula

$$n_f = \frac{n}{1+(\frac{n}{N})}$$

Where N is the size of the target population

Putting Z=1.96 for 95% level of confidence, p= 0.5 for 50% response distribution, and d= 0.1 for 10% margin of error gives n = 96. Since N = 653 then the estimated sample size n_f of 84 was obtained.

A 10% margin of error was used since the researcher was willing to tolerate a larger amount of error than the conventional 5% because the respondent were not expected to be split anywhere near the middle. Table 3.2 shows the number of cases from each category that was randomly selected for this study. A total of 84 companies were invited to take party in the study. The Random Numbers Generator, a software program created and developed by the researcher, was used to generate random numbers for each sector.

A five page questionnaire was constructed. It consists of the front page and two sections I and II. The front page contained a statement of the purpose of the project. Section I of the questionnaire asked the respondent to give the demographic details of their respective companies.

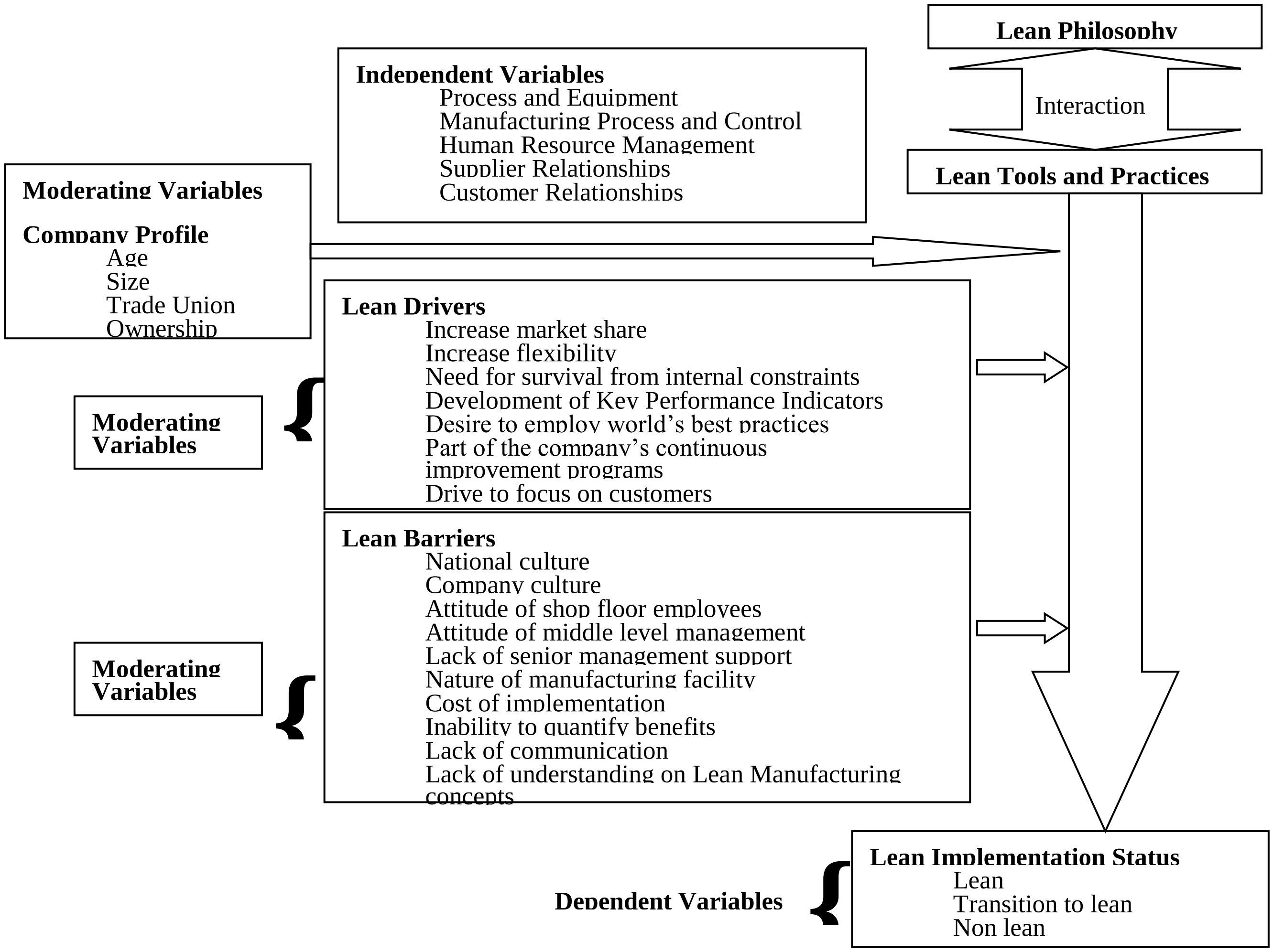

Fig 2: Conceptual model

These details included the name, size, age, and quality certification. It also asked for details of the respondent which consisted of the job title and number of years worked for that company. Section II of the questionnaire contained lean tools and practices and asked the respondent to rate on a scale of 1-5 the levels of adoption of the lean tools and practices that have been implemented in their respective organizations. The respondents were also asked to rate on a 1-5 likert scale the level of influence some seven lean drivers, frequently mentioned in literature, had on their organization's journey towards lean manufacturing. Ten barriers that hinder lean implementation were also be presented and the respondents asked to rate, on a likert scale of 1-5, their influencing on the company's Lean manufacturing implementation. Finally the respondents were asked to state the benefits they encountered as they implemented lean in their respective organizations.

Before the questionnaires were sent to the respondents a pilot study was undertaken to test the validity of the data collection instrument. Three persons competent in the field of production management were selected and requested to give their independent feedback as to how relevant the contents of the research instrument were for this study.

They were also be requested to make suggestions on how the questionnaire could be improved. They found the instrument to be satisfactory and did not suggest any changes to be incorporated in the final questionnaire. SPSS reliability analysis procedure using the Cronbach's alpha, which is based on the average inter-item correlation, was used to measure the internal consistency and hence the reliability of the questionnaire.

Each returned questionnaire represented a single case for SPSS analysis. Means and standard deviations were calculated and graphical displays of histograms, stem-and-leaf plots and the Q-Q Normality plots for each questionnaire item using the Explore procedure of the SPSS software made. The aim at this stage of data analysis was to describe the general distributional properties of the data, screen the data for input errors by identifying any unusual observations (outliers and extreme values) or any unusual patterns of observations that may cause problems for later data analyses. No unusual data were found and so the analysis commenced.

Mean scores and Standard Deviations for responses for each question were calculated separately using SPSS and reported in tables. In order to determine the lean status (non lean, in transition to lean, lean) of each respondent company, an agglomerative hierarchical cluster analysis using the Ward's minimum variance method and squared Euclidean distance interval measure was conducted from question 5 responses using the SPSS software. Ward's method was used to optimize the minimum variance between clusters. A one-way independent ANOVA, to determine the significance of the difference between the means of clusters was also performed for each factor. The purpose of this test was to examine the cluster's predictive validity and consistency with expected practice levels within groups. The Levene test was used to test for the homogeneity of variance. Where the means of clusters were found significant, post hoc tests were carried out using the Bonferroni test to determine the sources of variation of the cluster means.

Discriminant analysis was then performed to derive a classification rule for assigning manufacturing companies to one of the formed lean clusters on the basis of their mean scores on each of the five factors i.e. process and equipment, manufacturing planning and control, human resources management, supplier relationships, and customer relationships. The purpose of the discriminant analysis was to derive rules for classifying any manufacturing company in the Kenyan manufacturing sector on the basis of its observed mean values of the five factors. The SPSS discriminant analysis procedure was used.

IV. RESULTS

A total of 84 questionnaires were distributed through electronic mail to the 84 respondent companies that were selected to take part in the survey. Their email addresses were obtained from the Kenya Association of Manufacturers Directory 2013. All the 84 questionnaires were delivered. After two weeks 23 responses were received which represented a 27.4% response rate. Follow up telephone calls were made to the 61 companies that had not responded to the email questionnaire and the manager, in each company, requested to take part in the survey. An additional 9 responses were received which increased the number of responses received to 32 representing a 38.1% response rate. A final reminder was made to the 52 companies that had not yet responded. Another 5 responses were received bringing the total number of responses that were received to 37 representing a 44.0% response rate. This compares favorably with similar studies. For instance, [15] had 6.7%; [18] got 13.5%; [20] obtained 24.4%; [11] reported 40% and [9] had 62.5%. The reliability test, using the Cronbach's alpha, was carried out to measure the internal consistency of the research instrument. The results show that the survey instrument has a high internal consistency with Cronbach's alpha value of 0.824 and it was therefore reliable.

Majority of the respondents, 45.9%, were Production Managers while Engineering Managers came in second with 24.3%. Quality Control/Assurance Managers were 16.2%. Others job title holders accounted for only 13.5%. A large majority of the respondents (48.6%) had worked for less than 5 years for their current companies while 29.7% had worked for 5-10 years. Those who had worked for over 10 years for their current companies were only 21.6% which indicates a high turn-over rate of managers in the Kenyan manufacturing sector. The size of the company as represented by the number of permanent employees in its payroll at the time of the survey was investigated. Companies with less than 51 permanent employees were classifies as small, those with 51–150 were classified as medium sized while those with more than 150 permanent employees were classified as large companies. Small and medium sized companies were represented almost equally with 35.1% and 37.8% respectively while large companies constituted 27.0% of the respondent companies.

Another issue that was investigated was the quality management systems that had been awarded to the respondent companies. All the respondent companies reported that they had been certified for a quality management system. None of the respondent companies gave more than one quality management system under which they had been certified although it is common knowledge that some companies have been certified for more than one quality management system. Three quality management systems were reported. These were the ISO 9001:2008, ISO 14001 Environmental Management System, and the ISO 22000 Food Safety Management System. ISO 9001:2008 was the most popular quality management system with 67.67% of the respondent companies reporting to have been awarded. ISO 14001 EMS came in second with 27.0% while ISO 22000 FSMS was third with only 5.4%

It was also found out that 70.3% of those companies that took part in the survey had a trade union movement which represented their unionisable workers while 29.7% did not have a trade union movement for its workers. The age of the company was also investigated. Companies which had been in operation for less than 11 years were categorized as young companies; those with 11-20 years were categorized as intermediate while those with over 20 years in operation were categorized as old companies.

In order to investigate the extent of lean implementation in the Kenyan manufacturing sector, the respondent companies were asked to rate, on a scale of 1-5, the level of adoption of each of the lean tools and practices listed based on their current manufacturing practices. 5S (House keeping) is the leading lean practice in the Kenyan manufacturing sector, with a very high mean score of 4.43 and a standard deviation of 0.73. Other lean practices that have been extensively implemented in the Kenyan manufacturing sector include root cause analysis (M = 4.41, SD = 0.86), the daily schedules adherence (M = 4.32, SD = 0.97), preventive maintenance (M = 4.24, SD = 0.80), customer Just-In-Time link (M = 4.16, SD = 0.65), continuous flow (M = 4.05, SD = 0.97), and visual control (M = 4.00, SD = 0.78). Root cause analysis (4.41, SD = 0.86) is the leading lean tool used by the Kenyan manufacturing sector. However, visual stream mapping is rarely used and is the least of all the others (M = 1.57, SD = 0.65). Other lean tools that are not frequently used include small lot sizes (M = 2.11, SD = 0.91), leveled production or Heijunka (M = 2.22, SD = 0.79), Kanban (M = 2.35, SD = 1.34), cellular manufacturing (M = 2.46, SD = 1.22), setup reduction (M = 2.54, SD = 1.22), and Kaizen (M = 2.59, SD = 1.52). These lean tools and practices have a mean score of less than 3.0, which suggests that they have low levels of implementation in the respective companies.

Lean manufacturing tools and practices were also grouped into five factors or categories of process and equipment, manufacturing planning and control, human resources management, supplier relationships, and customer relationships. Customer relationships have the highest mean score (M = 3.59, SD = 0.71). It was followed closely by human resources management (M = 3.50, SD = 0.44). Supplier relationships come in third (M = 3.36, SD = 0.57) followed by process and equipment (M = 3.29, SD = 0.69). On the other hand manufacturing, planning and control has the lowest mean score (M = 3.00, SD = 0.60) implying that companies in the Kenyan manufacturing sector have problems incorporating the tools and practices listed under this factor in lean manufacturing. This contradicts [16] and [20] who reported that companies had more problems incorporating lean tools and practices relating to external relationships with customers and suppliers but was easier for them to incorporate internal ones like manufacturing, planning and control.

There are factors that cause organizations to implement lean manufacturing as part of a corporate strategy. These factors are referred to as lean drivers in this study. Respondents were asked to rate on a scale of 1-5 some commonly encountered lean drivers. The need to focus on customers has the greatest influence (M = 4.68, SD = 0.47). It was followed closely by desire to employ World's best practices (M = 4.03, SD = 0.87). Development of key performance indicator's, (M = 3.95, SD = 0.52), need for survival from internal constraints (M = 3.73, SD = 0.56) and increase in market share (M = 3.59, SD = 0.98) followed in that order. The least important factor is need for flexibility (M = 2.62, SD = 0.83) while company's continuous improvement programs come in sixth (M = 3.14, SD = 0.54).

The greatest barrier to lean manufacturing implementation was found out to be lack of understanding of manufacturing concepts (M = 4.65, SD = 0.68). This is in agreement with the findings in other studies ([16]; [20]; [9]; [11]). Other barriers that hindered implementation of LM were cost of Implementation (M= 4.49, SD= 0.61), inability to quantify benefits (M= 3.43, SD= 0.73), and nature of manufacturing facility (M= 3.16, SD= 0.87). Contrary to the findings by [20], national culture had the least effect (M= 1.57, SD= 0.83) followed by company culture (M= 1.70, SD= 0.70).

The purpose of this study was to uncover the lean manufacturing implementation status of the Kenyan manufacturing sector. This was achieved by carrying out an agglomerative hierarchical cluster analysis using the SPSS software. Fig 3 shows the agglomeration schedule that was generated.

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	12	13	.057	0	0	7
2	21	27	.156	0	0	12
3	1	4	.287	0	0	13
4	9	25	.439	0	0	17
5	15	19	.610	0	0	12
6	8	17	.783	0	0	18
7	10	12	.971	0	1	23
8	7	34	1.170	0	0	15
9	28	31	1.390	0	0	18
10	29	37	1.610	0	0	27
11	22	33	1.842	0	0	26
12	15	21	2.126	5	2	16
13	1	3	2.449	3	0	19
14	14	24	2.778	0	0	26
15	7	18	3.108	8	0	21
16	15	32	3.462	12	0	23
17	9	26	3.887	4	0	21
18	8	28	4.323	6	9	22
19	1	2	4.815	13	0	29
20	20	30	5.531	0	0	31
21	7	9	6.257	15	17	30
22	8	11	7.083	18	0	24
23	10	15	7.956	7	16	25
24	8	16	8.966	22	0	34
25	10	23	10.102	23	0	28
26	14	22	11.444	14	11	27
27	14	29	13.176	26	10	32
28	10	36	14.941	25	0	32
29	1	5	16.764	19	0	33
30	6	7	18.741	0	21	33
31	20	35	21.227	20	0	34
32	10	14	24.733	28	27	35
33	1	6	28.861	29	30	35
34	8	20	34.854	24	31	36
35	1	10	43.882	33	32	36
36	1	8	67.547	35	34	0

Fig 3. Agglomeration schedule

Fig 4 show the SPSS output of the dendrogram. From the dendrogram it can be seen that three clusters have formed. The first cluster consists of cases 12, 13, 10, 21, 27, 15, 19, 32, 23, 36, 29, 37, 22, 33, 14, and 24. The second cluster consists of cases, 1, 4, 3, 2, 5, 7, 34, 18, 9, 25, 26, and 6. The third cluster consists of cases 8, 17, 28, 31, 11, 16, 20, 30 and 35. These clusters correspond to non lean, in-transition-to lean and lean status respectively. In total 43.2% of the respondent companies were non-lean while 32.4% were in-transition-to lean and 24.3% were lean.

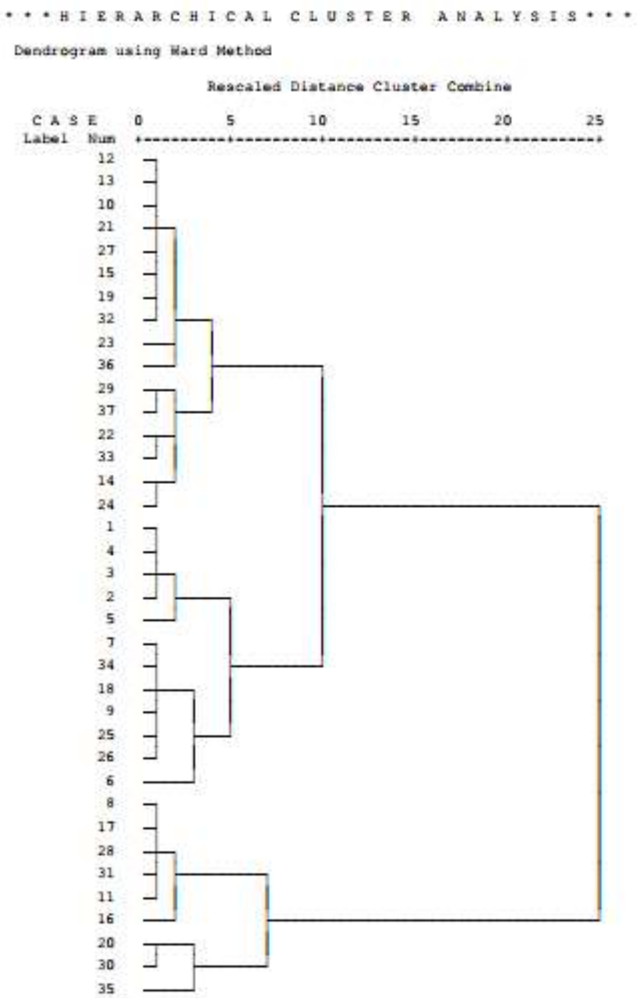

Fig 4. Dendrogram

In order to determine whether there were significant differences between the means of the three clusters, a one-way independent ANOVA test was carried out. The Levene test indicated that there was a non-significant difference at the 0.05 level for Process and Equipment, p= 0.203. Levene tests for the difference of cluster means for each of the other factors were also not found to be significant. Therefore the homogeneity of variance hypothesis was not rejected.

Post Hoc test was then carried out in order to determine the sources of variation of the means of clusters. The difference of the means of In-Transition-to Lean and non-lean clusters of p = 0.419 was not significant at the 0.05 level. However, the differences of the means of lean and non-lean and that of in-transition-to lean and lean were significant p = 0.000 and p = 0.001 respectively. Therefore the effect of Process and Equipment factor on lean implementation status was significant overall ($F (2, 34) = 16.583$; $p< 0.001$) and the effect size was strong at 0.494. However, post hoc tests indicate that the means for non-lean and in-transition-to lean did not differ significantly but both differed significantly from the mean of the lean cluster. This suggested that the lean tools and practices under Process and Equipment are important factors in determining the lean implementation status but do not distinguish between the non-lean and in-transition-to lean clusters.

The ANOVA test which was carried out separately for each factor showed that the F-test was significant for all five factors at the 0.05 level. An overall F value of 37.781 and its associated probability p= 0.000 for all five factors combined were also reported. This indicated that the differences in the cluster means were not due to individual differences of the respondents or due to experimental error but were due to their lean implementation status. The researcher therefore rejected the null hypothesis that the means of the three clusters is the same.

The effect of Manufacturing, Process and Control factor on lean implementation status was significant overall ($F (2, 34) = 7.522$; $p< 0.05$) and the effect size was strong at 0.411. However, post hoc tests indicate that the means for non-lean and in-transition-to lean did not differ significantly but both differed significantly from the mean of the lean cluster. This suggests that the lean tools and practices under Manufacturing, Process and Control are important factors in determining the lean implementation status but do not distinguish between the non-lean and in-transition-to lean clusters.

The effect of Human Resource Management factor on lean implementation status was significant overall ($F (2, 34) = 9.569$; $p= 0.001$) and the effect size was small at 0.238. However, post hoc tests indicate that the means of all the three clusters are not significant. This suggests that the lean tools and practices under Human Resource Management are important factors in determining the lean implementation status but are unable to distinguish between any of the three clusters.

The effect of Supplier Relationships factor on lean implementation status was significant overall ($F (2, 34) = 13.927$; $p<0.001$) and the effect size was medium at 0.396. Post hoc tests indicate that the means for lean and in-transition-to lean differed significantly but both did not differ significantly from the mean of the non-lean cluster. This suggests that the lean tools and practices under Supplier Relationships are important factors in determining the lean implementation status but can only distinguish between the lean and in-transition-to lean clusters.

The effect of Customer Relationships factor on lean implementation status was significant overall ($F (2, 34) = 34.715$; $p<0.001$) and the effect size was very strong at 0.737. However, post hoc tests indicate that the means for non-lean and in-transition-to lean did not differ significantly but both differed significantly from the mean of the lean cluster. This suggests that the lean tools and practices under Customer Relationships are important factors in determining the lean implementation status but do not distinguish between the non-lean and in-transition-to lean clusters.

A discriminant function analysis was carried out in order to derive classification rules that can be used to assign any manufacturing company in the Kenyan manufacturing sector to any of the three pre-determined clusters based on its mean scores on each of the five factors. The univariate ANOVA tests show that the differences of the cluster means for each factor are significant at the 0.05 level. The difference of the means of clusters for Process and Equipment is significant (F (2, 34)

=16.853; p<0.001), that for Manufacturing, Process and Control is also significant (F (2, 34) =7.522; p<0.05). The difference of the means of the three clusters for Human Resources Management is significant (F (2, 34) =9.569; p=0.001), that for Supplier Relationships is also significant (F (2, 34) =13.927; p<0.001), and the difference of the means of the three clusters for Customer Relationships is also significant (F (2, 34) =34.715; p<0.001). The Box's test for equality of co-variances show that these differences are statistically significant (F (30, 2378) = 1.652; p< 0.05). Two canonical discriminant functions were obtained as shown in Fig 5.

Factor	Function 1	Function 2
Mean for Process and Equipment	.887	.881
Mean for Manufacturing Planning and Control	.998	.207
Mean for Human Resource Management	-.160	1.617
Mean for Supplier Relationships	1.110	-.247
Mean for Customer Relationships	2.024	-.906
(Constant)	-16.364	-5.091

Fig 5. Canonical discriminant functions coefficients

The first discriminant function accounted for 84.6% of the variation while the second discriminant function accounted for only 15.4% of the variation. Wilk's Lambda statistics measures how well each discriminant function separates cases into clusters. It is equal to the proportion of the total variance in the discriminant scores not explained by differences among the clusters. Smaller values of Wilk's Lambda indicate greater discriminatory ability of the discriminant function. The Wilk's Lambda statistics were calculated from the canonical correlations. For instance, the first and the second Wilk's Lambda statistics were calculated as follows:

$\Lambda 1 = (1\text{-}0.9062)\,(1\text{-}0.6762) = 0.097290351936 = 0.097$ (3dp)
$\Lambda 2 = (1\text{-}0.6762) = 0.543024 = 0.543$ (3dp)

The Wilk's Lambda part indicates that both discriminant functions are statistically significant at the 0.05 level of significance. The first discriminant function was significant, $\Lambda = 0.097$, $\chi^2(10, N=37) = 74.703$, $p<0.001$. The second discriminant function was also significant, $\Lambda = 0.543$, $\chi^2(4, N=37) = 19.520$, $p=0.001$.

In order to derive the discriminant function equations, use was made of the unstandardized canonical discriminant function coefficients in Fig 5 and the territorial map shown in Fig 6. A territorial map was requested as part of the SPSS output during the discriminant function analysis procedure. It shows the area, on an X-Y plane, divided into three zones which represented the three clusters. The first discriminant function is plotted along the X-axis and the second discriminant function plotted along the Y-axis. The intersection point of the two discriminant functions locates the area, and so the cluster, to which that particular case belongs.

Let Z1 be the score of the first discriminant function
Z2 be the score of the second discriminant function
MPE represent the mean score of the Process and Equipment factor
MPC represent the mean score of the Manufacturing Planning and Control factor
MHR represent the mean score of the Human Resources Management factor
MSR represent the mean score of the Supplier Relationships factor
MCR represent the mean score of the Customer Relationships factor

Then
$Z1 = 2.024 * MCR + 1.11 * MSR + 0.998 * MPC + 0.887 * MPE - 0.16 * MHR - 16.344$

$Z2 = -0.906 * MCR + 0.247 * MSR + 0.207 * MPC + 0.881 * MPE + 1.617 * MHR - 5.091$

Z1 and Z2 are the two discriminant functions scores that could be used to assign any manufacturing company in the Kenyan manufacturing sector to any of the three lean clusters. From the territorial map, the following inequalities were derived and can be used to identify which cluster a manufacturing company should belong to when the Z1 and the Z2 scores are known. All the inequalities must be satisfied in each case.

Non-lean	In-transition to lean	lean
$Z2 \leq 1.67$	$Z1 \leq 1$	$Z1 \geq 1$
$Z2 \leq 1 + Z1$	$Z2 \geq 1 + Z1$	$Z2 \geq (34 - 22 * Z1)/9$
$Z2 \leq (34 - 22 * Z1)/9$		

A small computer program, nicknamed LeanStatus, was developed using the above algorithms to simplify and quicken the process of determining the lean status of any manufacturing company in the Kenyan manufacturing sector where its scores on each of the 28 lean tools and practices are known. LeanStatus correctly fitted all the 37 cases to their respective clusters representing a 100% success rate.

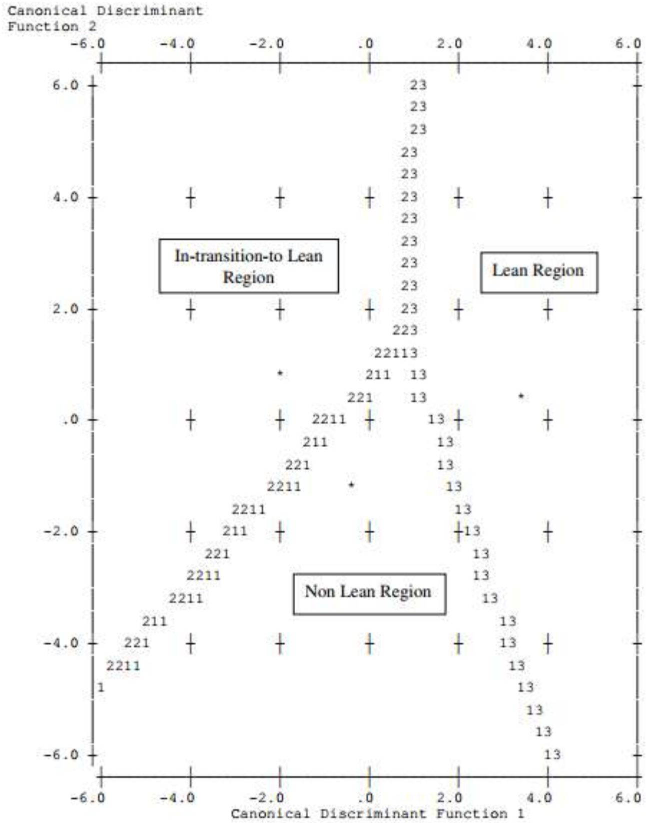

Fig 6. Territorial map

V. CONCLUSION

This study uncovered three lean implementation status that exists in the Kenyan manufacturing sector. These clusters are Non-lean, In-transition-to lean and Lean respectively. Lack of knowledge of the LM concepts came out as the single most reason why companies fail to implement lean manufacturing. Another significant finding is the fact that the Value Stream Mapping tool, an essential tool in lean implementation, is the least used in the Kenyan manufacturing sector contrary to the findings by [9] who found out that it is extensively used in the sugar sector. Kaizen initiatives, on their own, are not very beneficial without first using the Value Streaming Mapping tool to identify areas with waste reduction potential.

It was concluded from these findings that level of lean manufacturing implementation is low with 24.3% of the manufacturing companies practicing lean manufacturing. A lot of education and training on lean manufacturing and implementation of projects is required within the Kenyan manufacturing sector. Successful introduction of lean manufacturing takes time and requires widespread education, training and coaching. Some Kenyan manufacturing companies have respect for individuals, and practice kaizen and other lean tools. However, what is important is having all the elements together, including lean philosophy, as a system. It must be practiced every day in a very consistent manner.

VI. RECCOMENDATIONS

The following recommendations were made:

i. Top management in the Kenyan manufacturing sector should provide leadership in lean implementation in their respective companies.

ii. Manufacturing companies opting to implement lean manufacturing should train their employees, customers and suppliers on lean manufacturing.

iii. Universities in Kenya should start offering courses on lean manufacturing to help create and maintain standards to enhance learning and hence success of LM.

VII. SUGGESIONS FOR FURTHER RESEARCH

This study limited itself to seeking responses from highly qualified technical managers who included production, engineering and quality control managers and their equivalent. Response from shop floor employees and their supervisors, the people who do the actual implementation, were not sought. It was recommend that a study be done incorporating these cadres of workers in order to compare the two set of findings. Another suggestion is that other studies should compare the performance of lean companies, those in-transition to lean, and the non-lean companies in order to find out whether there is any significant difference in their productivity.

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