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EFFECT OF LEAN MANUFACTURING PRACTICES ON OPERATIONAL PERFORMANCE OF MANUFACTURING FIRMS IN MOMBASA COUNTY, KENYA

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ABSTRACT

Manufacturing firms operating in the presents' rapidly changing and highly competitive market have been pressured to improve all aspects of operational performance; quality, flexibility and customer response time as well as reduce costs of manufacturing. They have retorted by adopting a set of practices that is fast becoming the dominant paradigm in manufacturing - lean manufacturing. Lean manufacturing involves continuous elimination of waste from the value chain of manufacturers thus enhancing customer value through continuous improvement of operational performance of the manufacturers. This research sought to determine the effect of lean manufacturing practices on the operational performance of manufacturing firms in Mombasa County. The study was guided by to three objectives: To determine the extent to which manufacturing firms in Mombasa County have adopted lean manufacturing practices; To establish the effect of lean manufacturing practices on operational performance of manufacturing firms in Mombasa County and finally the challenges faced by firms when implementing lean manufacturing. The data analyzed was gathered using a semi-structured questionnaire targeting operations managers of manufacturing firms in Mombasa. The results were presented using tables, pie charts and were analyzed using descriptive statistics and regression models. The findings indicated that most manufacturing firms in Mombasa practiced lean manufacturing. It was also clear that lean manufacturing firms had seen an improvement in *their operational performance. The effect of lean manufacturing practices on the operational performance of manufacturing firms was tested against four operational performance metrics; quality, flexibility, speed and cost). The outcomes showed that lean manufacturing practices; just-in-time, continuous improvement/kaizen, value stream mapping and total productive maintenance; are positively related to operational performance while automation is negatively related to operational performance. The study also established that the most experienced challenge in adopting lean manufacturing was high costs of implementation and the least was lack of top management support. The study recommends more awareness of the importance of lean manufacturing practices in manufacturing firms and support from the top management as critical tool for takeoff. Most of all, the researcher urges manufacturing firms to implement lean manufacturing practices and create a culture that accommodates them since they have excellent systems and structures that can productively support it. If lean manufacturing practices are consistently implemented the operational performance of the manufacturing firms can significantly improve and this will enable manufacturing firms to survive the harsh business environment. The study also recommends that for lean manufacturing to be successful it should to be practiced within the entire supply chain.*

Keywords: Lean manufacturing, Operational performance, Business environment

INTRODUCTION

Firms are operating in a fast changing and highly competitive globalized market, thus pressuring them to improve quality, flexibility, and customer response. To achieve these improvements, researchers have increasingly proposed the implementation of lean principles in the manufacturing process as a way to achieve the required competitive advantage.

Lean manufacturing is a systematic approach that improves value to the customer by identifying and eliminating waste through continuous improvement by following the product at the pull of the customer in pursuit of perfection. Lean manufacturing as a business system for managing product development, operations, suppliers, and customer relations that requires less human effort, space, capital, and time to make products with fewer defects to precise customer desires.

Lean manufacturing involves creating more value for customers through waste minimization (using resources cautiously). Goldratt (1990) asserts that TOC views a manufacturing firm as system and there's always something that limits its performance. The main focus of lean manufacturing practices is on value, more than on cost, and seeks to remove all non-value adding components especially processes whilst improving those that add value (Womack & Jones 1996). This approach involves an extremely rigorous, questioning analysis of every detail of product development and production, seeking to continuously establish the ultimate source of problems. There are eight wastes highlighted in TPS; overproduction, waiting, conveyance, over processing, excess inventory, excess movement, defects and unused employee creativity, and the biggest is overproduction (Wee & Wu, 2009).

Lean manufacturing is a comprehensive set of practices that when combined and developed, make a company more flexible and more responsive to customer demand The major benefits of LM are increased productivity, improved product quality and manufacturing cycle time, reduced inventory, reduced lead time and elimination of manufacturing waste (Agus & Hajinoor, 2012), achieved through, continuous improvement (CI), total productive maintenance (TPM), jidoka, just-in-time (JIT), and value stream mappings (VSM) (Belekoukias, Garza-Reyes & Kumar, 2014).

Lean Manufacturing and Operational Performance

Operational performance refers to the measurable aspects of the outcomes of a firm's processes i.e. the effectiveness and efficiency of an organization in transforming inputs into outputs.

The determinant of operational performance is vital especially in the context of the current economic crises because it enables the identification of those factors that determine if there's indeed any progress or improvement in the operations of a manufacturing firm.

Organizations are adopting LM due to continued pressure to improve operational performance, pressure to maintain competitive advantage in price and service, pressure to improve profit, customers demanding shorter order-cycle times and reduced prices Wheatley (2005). LM practices are positively related to operational performance. LM is designed to eliminate waste and improve operations in every area extending from production to customer relations, supplier and factory management (Agus & Hajnoor, 2012). LM practices offer a manufacturing firm the platform to achieve superior operational performance (Womack & Jones, 2003). LM practices bear a direct relationship to improvements in operational performance (Agus & Hajinoor, 2012). LM philosophy if carefully adopted and implemented can definitely form the roadmap to global manufacturing excellence (Papadopoulou & Özbayrak, 2005).

Manufacturing Industry in Mombasa

Mombasa is the second-largest city in Kenya, and is home several giant manufacturing firms which include, the Kenya Petroleum Oil Refinery, Bamburi Cement, several steel manufacturers, and bottling companies. Other manufacturing firms within the county are the export processing zones and small and medium scale manufacturing firms such as bakeries and plastic manufacturers. The study focused on Mombasa as it was familiar and could be easily accessed by researcher to save time and cost.

Research Problem

This study particularly focused the effect of adopting LM practices on the operational performance of manufacturing firms in Mombasa County?

Research Objectives

The objective of this study is;

I. To determine the effect of lean manufacturing practices on the operational performance.
II. To determine the extent to which manufacturing firms in Mombasa County have adopted lean manufacturing practices.
III. To establish the effect of lean manufacturing practices on operational performance of manufacturing firms in Mombasa County.
IV. To find out the challenges faced by manufacturing firms in Mombasa County when adopting lean manufacturing practices.

LITERATURE REVIEW

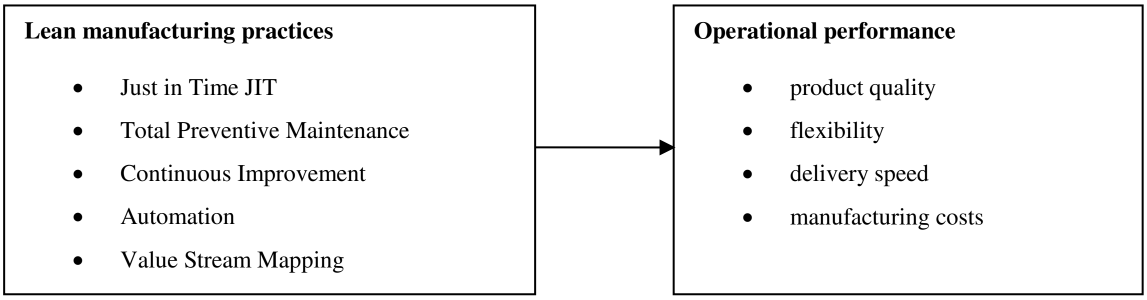
This study is anchored on two theories; the theory of constraints and the resource-based view

- Theoretical Foundation of the Study
- Theory of Constraints (TOC)
- Resource Based Theory (RBV)
- Just-in-Time (JIT)
- Lean Manufacturing Practices
- Total Productive Maintenance (TPM)
- Continuous Improvement/Kaizen
- Automation/Jidoka
- Value Stream Mapping (VSM)
- Challenges of Adopting Lean Manufacturing

This study is guided by the following conceptual framework model:

Figure 1: Conceptual Framework

Independent Variable **Dependent Variable**



The regression analysis was used and the findings were presented in tables. The value of the coefficient of correlation (R) was computed to determine the magnitude and direction of the relationship. The models were constructed using the lean practices and operational metrics discussed in the study as follows:

$$Y_1 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$
$$Y_2 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$
$$Y_3 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$
$$Y_4 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$
$$Y_0 = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$

Y_0 was the dependent variable representing operational performance, Y_1 was product quality metric, Y_2 was flexibility metric, Y_3 was delivery speed metric and Y_4 was manufacturing costs metric; β_0 was a constant factor which was also the value of the dependent variable when X_1, X_2, X_3, X_4 & X_5 are equal to zero. X_1 was JIT variable, X_2 was TPM variable, X_3 was CI variable and X_4 was jidoka variable and X_5 was VSM variable. β_1, β_2, β_3, β_4 and β_5 are constants associated with X_1, X_2, X_3, X_4 and X_5 respectively. Random error ε represents all other minor effects on the model which were captured. The measures used in this study were derived from several criteria, which have been conceptualized and used in previous empirical studies on LM and operational performance (Belekoukias et al., 2014).

Data analysis and Findings

The number of questionnaires presented to the respondents was fifty (50) and a total of forty-two (42) questionnaires were completed satisfactorily and returned; this gave the study an eighty four percent response rate.

Table 1: Response by Manufacturing Firms

Sector	Pop. size	Sample size	Response
Building construction & mining	7	4	4
Chemical and allied	10	2	2
Fresh produce	0	0	0
Energy, electrical & electronics	6	2	2
Food and beverages	24	10	9
Leather and footwear	0	0	0
Metal and allied	16	7	7
Motor vehicle and Accessories	7	3	1
Paper and paperboard	4	2	1
Pharmaceutical & Med equip	2	1	1
Plastic and Rubber	9	3	2
Services and Consultancy	27	10	7
Textile and Apparels	18	7	4
Timber, wood and furniture	0	0	0
Total	**130**	**50**	**42**

Table 1 shows that various sub-sectors in the manufacturing sector and they were adequately represented in the research data.

Firms' Operation Period

The study sought to determine the period of time the firms under study had been in operation, help the researcher determine if the firms were experienced in manufacturing.

Table 2: Duration in Business

Duration (years)	Frequency	Percent
1 - 3	1	2.4
3 - 5	9	21.4
5 - 10	16	38.1
Over 10	16	38.1

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Duration (years)	Frequency	Percent
1 - 3	1	2.4
3 - 5	9	21.4
5 - 10	16	38.1
Over 10	16	38.1
Total	**42**	**100.0**

The respondents were asked to indicate the number of years they have been in business. Majority of the respondents representing 38.1% responded that they have been in business for 5-10 years and for over 10years respectively. 21.4% of the respondents indicated that they have been in business for 3-5 years, also 2.4% of the respondents said they have been in business for 1-3 years. From the results it can be inferred that majority of the firms were in business long enough to develop certain learning curve to start employing lean manufacturing.

Annual Turnover

The researcher sought to find out the annual turnover of manufacturing firms in Mombasa County.

Table 3: Annual Turnover

Annual turnover	Frequency	Percent
less than kshs 500,000	1	2.4
less than kshs 1 million	1	2.4
less than kshs 2 million	6	14.3
over kshs 2 million	34	81.0
Total	**42**	**100.0**

It can be seen that majority of the respondents (81%) indicated that their turnover was over kshs 2million. 14.3% indicated that their annual turnover was less than kshs 2million, while 2.4% said that their turnover was less than kshs 500,000. From these results it can be inferred that the majority of the respondents have an annual turnover of more than kshs 2million and thus can afford to practice lean manufacturing.

Improvement in Operational Performance

The respondents were asked to indicate if there was improvement in operational performance; all the respondents representing 100% responded that there was improvement in operational performance.

Table 4: Improvement in Operational Performance

Response	Frequency	Percent

Yes	42	100%
No	0	0%
Total	**42**	**100.0**

Extent of Adoption of Lean Manufacturing Practices

The respondents were asked to indicate the extent to which they had adopted LM practices. The information was collected by use of a Likert scale with 1 representing no implementation, 2 representing little implementation, 3 representing some implementation, 4 representing extensive implementation, 5 representing complete implementation. The responses are subjected to descriptive statistics and the findings are as presented in the following subsections.

Just-in-Time (JIT)

The respondents were asked to indicate the extent to which they had adopted certain JIT elements.

Table 5: Just in Time

Elements of JIT	Mean	Std deviation	Rank
Production of products with same components and spares	3.81	.707	4
Reduced inventory levels and spare requirements	4.33	.687	3
Faster response to customer demands and order	4.60	.497	1
Output as per demand (Pull production)	4.38	.539	2
Average	**4.28**	**.608**	**3**

The average mean for just in time implementation practice was 4.28 this confirms that JIT is an extensively adopted LM practice in manufacturing firms in Mombasa County. The study established that JIT was implemented where there was need to reduce inventory levels and creation of space. It was also revealed that JIT was mainly implemented by the manufacturing to fasten response to customers' demands and orders and increase output per demand with a mean of 4.60 and 4.33 respectively.

Continuous Improvement/Kaizen

Table 6: Continuous Improvement/Kaizen

Elements of Kaizen	Mean	Std deviation	Rank
Incremental improvement of manufacturing process	4.67	.707	1
Improved customer service and product quality	4.40	.477	2
Improving teamwork and innovation	4.60	.522	3
Average	**4.44**	**.532**	**2**

It can be observed from table 6 that the total average mean for the extent to which kaizen had been adopted by the manufacturing firms was found to be 4.44. The study revealed that Kaizen had been adopted by manufacturing firms in Mombasa to a large extent. The continuous improvement the manufacturing process had a high mean score of 4.67. Kaizen was also put into practice to improve product quality and enhance customer services with the second highest mean of 4.4. The impact of Kaizen in improving team work and innovation was sturdily felt with a mean score of 4.24.

Total Productive Maintenance (TPM)

The researcher sought to establish the extent to which certain TPM practices had been adopted by manufacturing firms in Mombasa County.

Table 7: Total Productive Maintenance

Elements of TPM	Mean	Std deviation	Rank
Shared responsibility for equipment	3.95	.439	3
Operators maintain their own equipment	4.00	.625	2
Improving teamwork and innovation	4.60	.539	1
Average	**4.19**	**.534**	**4**

From the findings presented in table 7, the study established that TPM had been extensively adopted by manufacturing firms in Mombasa County with the average mean for TPM was 4.19. The maximized use of plant equipment had a mean of 4.62 meaning most respondents felt that TPM had helped the use their equipment for a longer time. Operators had been empowered to maintain their own equipment having a mean of 4.00 and lastly shared responsibility for equipment which had a mean of 3.95.

Automation/Jidoka

The study sought to establish the extent to which jidoka practice had been adopted by manufacturing firms in Mombasa County.

Table 8: Jidoka Practice

Elements of Jidoka	Mean	Std deviation	Rank
Assist workers with masculine requirements of work	4.45	.670	2
Workers can monitor multiple stations	4.62	.539	1
Improving teamwork and innovation	4.36	.485	3
Average	4.48	.565	**1**

The study established that jidoka was primarily the most adopted LM practice by manufacturing firms in Mombasa County. This is according to the findings presented in table 4.8 because it had an average mean score of 4.48. It can be also deduced that jidoka enables workers to monitor multiple stations with a mean of 4.62 was viewed by respondents to have been completely implemented. This was followed by assist workers with masculine requirements of work which had a mean of 4.45 and the least jidoka practice implemented was quickly identify and resolve manufacturing issues which had a mean of 4.36. This shows that jidoka was completely implemented by manufacturing firms in Mombasa County.

Value Stream Mapping (VSM)

The researcher sought to determine the extent to which VSM practice had been adopted by manufacturing firms in Mombasa County. The respondents were asked to indicate the extent of VSM adoption.

Table 9: VSM Practice

Elements of VSM	Mean	Std deviation	Rank
Interpreted flow of information and materials	4.10	.370	2
Visual picture of current and future objectives	4.02	.563	3
Improved communication and teamwork	4.21	.470	1
Average	4.11	.468	**5**

The results in table 9 indicate that VSM had also been considerably implemented by manufacturing firms in Mombasa County. It is represented by a mean of 4.11 and standard deviation of 0.468. The findings of the study also reveal that VSM helped improve communication and team work since it had a mean of 4.21. This is achievable because the manufacturing firms in Mombasa County had clearly interpreted flow of information and materials within their firms observed with a mean of 4.10. Lastly, the researcher concludes that the firms were visionary since both current and future objectives represented by a mean of 4.02 towards improving their performance.

Summary of Lean Manufacturing Practices

In this section the researcher sought to compare the rate of adoption of all lean manufacturing practices.

Table 10: Lean Manufacturing Practices

LM practices	Mean	Std deviation	Rank
Just in time (JIT)	4.28	.608	**3**
Continuous improvement/ kaizen	4.44	.532	**2**
Total productive maintenance (TPM)	4.19	.534	**4**
Automation/ Jidoka	4.48	.565	**1**
Value stream mapping (VSM)	4.11	.468	**5**

The lean manufacturing practices were analyzed to find out the extent to which they had been adopted by the manufacturing firms in Mombasa County. From the results, almost all of the manufacturing firms had extensively implemented automation which had a mean of 4.48, and kaizen was the subsequent most adopted LM practice, followed by JIT and TPM practices respectively. According to the research, VSM was the least implemented LM practice with a mean of 4.11. From the results we can deduce that there is extensive LM adoption by manufacturing firms in Mombasa County.

The Figure 1 shows a pictorial representation of the extent to which manufacturing firms in Mombasa County had adopted the various LM practices. It shows that LM practices had been robustly and uniformly adopted by manufacturing firms in Mombasa County.

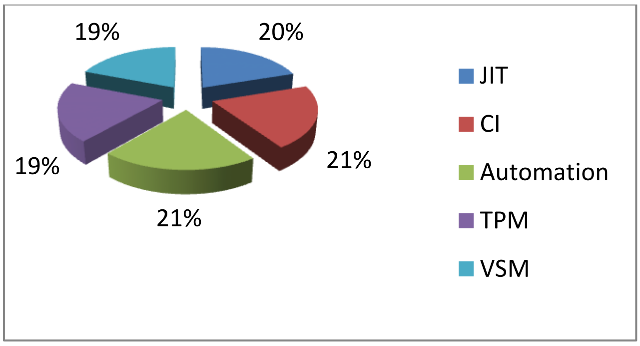

Figure 1: The Extent of Adoption of Various LM Practices by Manufacturing Firms in Mombasa County

The Relationship between LM and Operational Performance

The LM practices were rated on a 1 - 5 scale against various operation performance indicators. The average responses obtained for each of the aspects of the extent of adoption of LM practices and composite operational performance are presented in table 4.11.

Where:

X_1 = JIT
X_2 = Continuous improvement/Kaizen (CI)
X_3 = Total preventive maintenance (TPM)
X_4 = Automation/Jidoka
X_5 = Value stream mapping (VSM)
Y_1 = Product quality
Y_2 = Flexibility
Y_3 = Delivery speed
Y_4 = Manufacturing costs
Y_0 = Operational performance index

The researcher then applied the regression models to determine the relationship between lean manufacturing practices and operational performance. The models were obtained using the data presented in table11.

Table 11: Average Responses of Each Aspect of LM and Corresponding Operational Performance Metric

	X1	X2	X3	X4	X5	Y1	Y2	Y3	Y4	YO
1.	4.5	5	4.33	5	4	4	5	4.67	4	4.42
2.	4	5	4.33	4.67	4	4.33	4.33	5	4	4.42
3.	4.25	4.67	4.33	4.67	4	4	4.33	5	4.67	4.5

4.	4.5	4.33	3.67	4.67	4.33	4	4	4	5	4.25
5.	4.75	4	4.33	4.67	4.33	4.33	4.67	4.67	4	4.42
6.	3.5	4.33	4	5	4.33	4	3.67	4	4	3.97
7.	4.75	4	4	5	4	4	5	4.33	4	4.33
8.	4.5	4.67	4.33	4	4	4.33	4.67	4.33	4	4.33
9.	4	5	4.67	4.67	4.67	4	4	4	4	4
10.	5	4.67	4.33	5	4.67	4.67	5	4.67	5	4.83
11.	3.25	3.33	3	3.67	3	3.33	3.33	4	3	3.46
12.	4.75	4	5	4	4	4.67	5	5	4.33	4.75
13.	4	5	4	4	4.33	4.67	4	5	5	4.67
14.	4.75	4.67	4	4.67	4	4	4	4	4	4
15.	4.75	4.67	4.33	5	4.33	4	4.67	5	4	4.42
16.	4.75	3.67	4.33	4.67	4	3.67	4	3.67	4	3.83
17.	4	5	4.67	4.67	4.33	5	4	4.33	4	4.33
18.	4	4.67	4.33	4	4	4	5	5	5	4.75
19.	3.75	4.33	4.67	4.33	4	4	4	4.67	4.67	4.33
20.	4.5	4	4.33	4	4	4	4.33	4	4	4.08
21.	4.5	4.33	3.67	4.67	4	4.67	4.33	4.67	4.67	4.58
22.	4.25	4	4	4	4	4	4	4	4	4
23.	4.5	4.67	4.67	4.67	4.33	4	4.33	4.33	4	4.17
24.	4	4.33	4.33	4	4	4	4.33	4	4	4.08
25.	4.75	5	4.67	4.67	4.33	4	4.67	4.67	5	4.58
26.	4.75	4.33	4.33	4	4	4.67	4.67	4	4	4.33
27.	4	4	4	4	4	4	4	4	4	4
28.	3.5	4.33	4	4.33	4	4	4	5	4	4.25
29.	4.5	4.67	4	4.67	3.67	4.33	4.33	4.67	4.33	4.42
30.	4.75	4	4.33	4.67	4.33	4.33	4.67	4.67	5	4.67
31.	4	4	4.67	4.67	4.33	4	4.33	4	4	4.08
32.	4.5	5	4.67	5	4	4.33	4	4	4.67	4.25
33.	4.25	4.67	3.33	4.33	4	4.33	4.33	4.33	4	4.25
34.	5	4.67	4.33	5	4.33	4	4	4	4	4
35.	4.25	4.33	4.67	4.67	4	4.33	4.67	4	4	4.25
36.	4	5	4	4.67	3.67	4	4.33	4	4	4.08
37.	4.5	4.33	4.33	4.67	4	4.33	4	4.33	4	4.17
38.	3.25	3.67	3.33	3	3.33	3	4	4	3.67	3.67
39.	4	4	3.67	4.33	4.33	4.33	3.67	3.33	3.67	3.75

40.	3.75	4	4	4	4.67	4.33	5	4	5	4.58
41.	4	5	4	4.67	4	4.67	4	4	4	4.17
42.	4.5	5	4	5	5	5	5	5	4.67	4.92

This section aimed to establish the effect of LM practices and operational performance using regression analysis. The Operational metrics considered were Product quality, flexibility, delivery speed and manufacturing costs represented as Y_1, Y_2, Y_3, & Y_4 respectively.

Effect of Lean Manufacturing Practices on Product Quality

The researcher sought to establish the effect of lean manufacturing practices on product quality (Y_1).The independent variables (X_1, X_2, X_3, X4, and X_5) were regressed against the dependent variable (Y_1).

Table 12: Summary Product Quality Metric

Summary Output of Product Quality	
Regression Statistics	
Multiple R	0.646
R Square	0.418
Adjusted R Square	0.337
Standard Error	0.313
Observations	42

a. Predictors: Value stream mapping (VSM), just in time, continuous improvement/ kaizen, automation/jidoka, total product maintenance (TPM)

b. Dependent Variable: product quality(Y_1)

From data in table 12 the adjusted R^2 is 0.337 which means that 33.7% variation in product quality is accounted for by the variation in lean manufacturing practices. The correlation coefficient tells us the strength of the relationship between the variables. The study found that the correlation coefficient was 0.646 thus there was a strong positive correlation between the lean manufacturing practices and product quality.

Table 13: Analysis of Variance of Product Quality

ANOVA					
	df	***SS***	***MS***	***F***	***Significance F***
Regression	5	2.530	0.506	5.167	0.001
Residual	36	3.526	0.098		
Total	41	6.056			

a. Predictors: Value stream mapping (VSM), Just in time, Continuous improvement/ kaizen, automation/Jidoka, Total product maintenance (TPM)

b. Dependent Variable: product quality(Y_1)

From the ANOVA table 4.13 the significant value for the model was 0.001 which means that the model was significant since the value is lower than 0.05.

Table 14: Regression Analysis Coefficients of Product Quality

	Coefficients	*Std Error*	*t Stat*	*P-value*
Intercept	0.731	0.720	1.015	0.317
X_1 (JIT)	0.195	0.134	1.454	0.155
X_2 (CI)	0.303	0.131	2.306	0.027
X_3 (TPM)	-0.018	0.139	-0.127	0.900
X_4 (Jidoka)	-0.122	0.153	-0.796	0.431
X_5 (VSM)	0.460	0.173	2.654	0.011

Source research data, 2014

$$Y_1 = 1.355 + 0.195X_1 + 0.303X_2 - 0.018X_3 - 0.122X_4 + 0.460X_5 + 0.73$$

From the equation the study found that holding value stream mapping (VSM), just-in-time, continuous improvement/kaizen, automation/jidoka and total product maintenance (TPM) to constant zero, product quality (dependent variable Y_1) of lean manufacturing firms would be 1.355. This means the product quality of a manufacturing firm would improve positively.

A factor increase in JIT would lead to an increase in product quality factor of 0.195, a unit increase in CI would lead to an increase in product quality by 0.303, an increase in a unit of TPM by a factor of one would lead to a decrease of 0.018 of the firm's product quality, a unit increase in jidoka would lead to decrease in product quality by 0.122, a unit increase in VSM would lead to a 0.46 increase in product quality. This information shows that there's a positive relationship between JIT, kaizen and VSM and product quality. It also showed that there was a negative relationship between jidoka, TPM and product quality.

This regression model may not be useful in forecasting the product quality given that the parameter values of the independent variables are not all significant (some are more than 0.05) in explaining the variation in product quality.

Effect of Lean Manufacturing Practices on Flexibility

The researcher sought to determine the effect of lean manufacturing practices on flexibility (Y_2). The independent variables (X_1, X_2, X_3, X4, and X_5) were regressed against the dependent variable (Y_2).

Table 15: Summary of Flexibility Metric

Summary Output of Flexibility	
Regression Statistics	
Multiple R	0.595
R Square	0.354
Adjusted R Square	0.264
Standard Error	0.366
Observations	42

From data in table 15 the adjusted R^2 was a 0.264 which means 26.4% variation in flexibility metric is accounted for by the variation in VSM, JIT, CI/kaizen, jidoka and TPM. The correlation coefficient (R) tells us the strength of the relationship between the variables. The study found that the correlation coefficient was 0.595 thus there was a positive correlation between the lean manufacturing practices and flexibility metric.

Table 16: Analysis of Variance of Flexibility Metric

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	2.640	0.528	3.947	0.0059
Residual	36	4.815	0.134		
Total	41	7.46			

a. Predictors: Value stream mapping (VSM), Just in time, Continuous Improvement/ Kaizen, Automation/Jidoka, Total product maintenance (TPM)

b. Dependent Variable: flexibility

From the ANOVA results in table 4.16 the significant value for the model was 0.005 which means that the model was statistically significant since it is lower than 0.05.

Table 17: Regression Coefficients of Flexibility Metric

	Coefficients	*Std Error*	*t Stat*	*P-value*
Intercept	1.324	0.842	1.572	0.125
X_1 (JIT)	0.461	0.157	2.939	0.006
X_2 (CI)	0.094	0.154	0.614	0.543
X_3 (TPM)	0.164	0.163	1.008	0.320
X_4 (Jidoka)	-0.285	0.178	-1.600	0.118
X_5 (VSM)	0.292	0.203	1.442	0.158

$$\mathbf{Y_2=1.324+0.461X_1+ 0.094X_2 + 0.164X_3 - 0.285X_4+ 0.292X_5 + 0.842}$$

From the equation the study found that holding value stream mapping (VSM), just in time, continuous improvement/ kaizen, automation/jidoka and total product maintenance (TPM) to constant zero, flexibility (dependent variable Y_2) of lean manufacturing firms would be 1.324.

A factor increase in JIT, CI, TPM and VSM would lead to an increase in flexibility metric by 0.461, 0.094, 0.164 and 0.292 respectively. Consequently, a unit decrease in automation would lead to a 0.28 increase in operational performance. This information shows that there’s a positive relationship between, JIT, CI, TPM and VSM and flexibility metric and a negative relationship with jidoka.

This regression model may not be useful in forecasting the flexibility because not all the parameter values of the independent variables are significant (some are more than 0.05) in explaining the variation in flexibility.

Effect of Lean Manufacturing on Delivery Speed

To establish the effect of lean manufacturing practices on delivery speed variable (Y_3).The independent variables (X_1, X_2, X_3, X4, and X_5) were regressed against the dependent variable (Y_3). The results are as shown in table 4.18:

Table 18: Summary of Delivery Speed Metric

Summary Output of Delivery Speed	
Regression Statistics	
Multiple R	0.400
R Square	0.160
Adjusted R Square	0.044
Standard Error	0.430
Observations	42

From data in the Table18 the adjusted R^2 was 0.044 which means 4.4% variation in delivery speed is accounted for by the variation in lean manufacturing practices. The correlation coefficient in this case was 0.400 and thus there was a positive correlation between the lean manufacturing practices and delivery speed.

Table 19: Analysis of Variance of Delivery speed

		ANOVA			
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.267	0.253	1.374	0.257
Residual	36	6.639	0.1844		
Total	41	7.906			

a. Predictors: value stream mapping, just in time, continuous improvement/ kaizen, automation/jidoka, total product maintenance

b. Dependent Variable: Delivery speed (Y_3)

From the above ANOVA table the significant value for the model was 0.257 which means that the model was statistically not significant since the value was higher than 0.05.

Table 20: Regression Analysis Coefficients of Delivery Speed

	Coefficients	*Std Error*	*t Stat*	*P-value*
Intercept	2.333	0.989	2.360	0.024
X_1 (JIT)	0.102	0.184	0.555	0.582
X_2 (CI)	0.3669	0.180	2.035	0.049
X_3 (TPM)	0.113	0.191	0.590	0.558
X_4 (Jidoka)	-0.113	0.209	-0.541	0.591
X_5 (VSM)	-0.005	0.237	-0.022	0.982

$$Y_3=2.333 + 0.102X_1 + 0.3669X_2 + 0.113X_3 - 0.113X_4 - 0.005X_5 + 0.989$$

The equation indicates that holding Value stream mapping (VSM), just in time, continuous improvement/ kaizen, automation/jidoka and total product maintenance (TPM) to constant zero, delivery speed index (dependent variable Y_3) of lean manufacturing firms would improve by 2.333.

A factor increase in JIT, CI and TPM would lead to an increase in delivery speed metric by 0.102, 0.367 and 0.113 respectively. Consequently, a unit decrease in automation and VSM would lead to a 0.11 and 0.005 increase in delivery speed. This information shows that there's a positive relationship between, JIT, CI and TPM and delivery speed metric and it has a negative relationship with jidoka and VSM.

This regression model might not be useful in forecasting the delivery speed given that the parameter values of the independent variables are not all significant (some are more than 0.05) in explaining the variation in delivery speed.

Effect of Lean Manufacturing Practices on Manufacturing Costs

The study sought to ascertain the effect of lean manufacturing practices on manufacturing costs (Y_4).The independent variables X_1, X_2, X_3, X4, and X_5 were measured against the Y_4 as the dependent variable using regression analysis. The results are as presented in table 21.

Table 21: Summary of Manufacturing Costs

Summary Output of Manufacturing Costs	
Regression Statistics	
Multiple R	0.580
R Square	0.336
Adjusted R Square	0.244
Standard Error	0.398
Observations	42

Source: Research data, 2014

From data in table 21 the adjusted R^2 was 0.244 which means that 24.4% variation in manufacturing cost is accounted for by variation in lean manufacturing practices. The correlation coefficient tells us the strength of the relationship between the variables. The study found that the correlation coefficient was 0.580 thus there was a strong positive correlation between the lean manufacturing practices and manufacturing costs index.

Table 22: Analysis of Variance of Manufacturing Costs

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	2.889	0.578	3.644	0.009
Residual	36	5.709	0.159		
Total	41	8.598			

a. Predictors: Value stream mapping, just in time, continuous improvement/ kaizen, automation/jidoka, total product maintenance.

b. Dependent Variable: Manufacturing costs index(Y_4)

Findings from the ANOVA table 4.22 prove that the model is statistically significant since the significant value was 0.009 which is lower than 0.05

Table 23: Regression Analysis Coefficients of Manufacturing Costs

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.746	0.917	0.814	0.421
X_1 (JIT)	0.216	0.171	1.267	0.213
X_2 (CI)	0.253	0.167	1.514	0.139
X_3 (TPM)	0.004	0.177	0.027	0.979
X_4 (Jidoka)	-0.266	0.194	-1.371	0.177
X_5 (VSM)	0.633	0.220	2.870	0.007

Source: Research data, 2014

$$\mathbf{Y_4 = 0.746 + 0.216X_1+0.253X_2+0.004X_3-0.267X_4+0.632X_5+ 0.917}$$

From the equation the research proved that holding VSM, JIT, CI/kaizen, jidoka and TPM to constant zero, the manufacturing costs metric (dependent variable Y_4) of lean manufacturing firms would improve by 0.746.

A factor increase in JIT, CI TPM and VSM would lead to an improvement in the manufacturing costs metric by 0.216, 0.253, 0.004 and 0.632 respectively. Consequently, a unit decrease in automation would lead to a 0.267 improvement in manufacturing costs. This information shows that there's a positive relationship between, JIT, CI, TPM and VSM and manufacturing costs metrics and there is a negative relationship with jidoka.

This regression model may not be useful in forecasting the manufacturing costs because not all the parameter values of the independent variables are significant (some are more than 0.05) in explaining the variation in manufacturing costs.

Effect of Lean Manufacturing on Operational Performance

The main aim of the study was to establish the effect of lean manufacturing practices on operational performance (Y_0). The independent variables (X_1, X_2, X_3, X4, and X_5) were regressed against the dependent variable (Y_0). The findings are as presented in table 4.24.

Table 24: Regression Model Summary of Operational Performance

Summary of Operational Performance	
Regression Statistics	
Multiple R	0.665
R Square	0.443
Adjusted R square	0.365
Std Error	0.252
Observations	42

From the table 24 the adjusted R^2 was 0.365 which means 36.5% variation in operational performance is accounted for by variation in lean manufacturing practices. The correlation coefficient tells us the strength of the relationship between the variables. The study found that the correlation coefficient was 0.665 thus there was a strong positive correlation between the lean manufacturing practices and operational performance.

Table 25: Analysis of Variance of Operational Performance

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.816	0.363	5.723	0.0005
Residual	36	2.284	0.063		
Total	41	4.100			

a. Predictors: Value stream mapping (VSM), just in time, continuous improvement/ kaizen, automation/jidoka, total product maintenance (TPM)

b. Dependent Variable: Operational performance index

From the above ANOVA table the significant value for the model was 0.001 which means that the model is significant since it was lower than 0.05.

Table 26: Regression Analysis Coefficients of Operational Performance

	Coefficients	*Std Error*	*t Stat*	*P-value*
Intercept	1.355	0.580	2.336	0.025
X_1 (JIT)	0.231	0.108	2.134	0.040
X_2 (CI)	0.248	0.106	2.346	0.025
X_3 (TPM)	0.061	0.112	0.540	0.593
X_4 (Jidoka)	-0.184	0.123	-1.493	0.144
X_5 (VSM)	0.340	0.140	2.435	0.022

$$\mathbf{Y_0 = 1.355 + 0.231X_1 + 0.248X_2 + 0.061X_3 - 0.184X_4 + 0.340X_5 + 0.58}$$

The study derived this equation which shows the value of improvement of operational performance of manufacturing firms when holding JIT, CI. TPM, Jidoka and VSM to constant zero would be 1.355.

A factor increase in JIT would lead to an increase in operational performance by 0.231, a unit increase in continuous improvement would lead to an increase in operational performance by 0.248, an increase in TPM by a factor of one would lead to an increase of 0.061 in the firm's operational performance, a unit increase in automation or jidoka would lead to a decrease in OP by 0.184 and a unit increase in VSM would lead to a 0.340 increase in operational performance. This information shows that there's a positive relationship between, JIT, continuous improvement/ kaizen, total product maintenance and value stream mapping and operational performance. The findings also show that there was a negative relationship between automation and operational performance.
This regression model may not be useful in forecasting the operational performance given that not all the parameter values of the independent variables are significant (some are more than 0.05) in explaining the variation in operational performance.

Challenges of Adopting Lean Manufacturing Practice

Table 27: Challenges of Adopting LM Practices

Challenge	Mean	Std. Deviation	Rank
Resistance to change	3.83	.581	4
Lack of top management support	3.52	1.042	7
Failure to implement lean into the supply chain	4.24	1.031	2
Wrong implementation sequence	3.98	1.093	3
Customer dissatisfaction	3.55	1.131	6
Plant size issues	3.74	1.191	5
High costs of implementation	4.26	1.191	1
Any other challenge (specify)	0	0	8

From the table above, its agree that high cost of implementation was the mostly encountered challenge in adoption lean manufacturing practices since it had the highest mean of 4.26. Failure to implement lean into the supply chain was next with a mean of 4.24, and then wrong implementation sequence which had a mean of 3.98 this was closely followed by resistance to change which had a mean of 3.83. The least encountered challenge of adopting lean manufacturing was lack of top management support which had a mean of 3.52. No other challenges were cited by the respondents.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study established the extent to which manufacturing firms in Mombasa County have adopted lean manufacturing practices;
The outcome provided an insight on the extent to which manufacturing firms in Mombasa County have adopted lean manufacturing practices. Just-in-time, continuous improvement, total productive maintenance, jidoka and value stream mapping were the LM practices considered the respondents

agreed that the manufacturing firms have extensively adopted lean manufacturing practices. JIT and automation were viewed by the respondents as decidedly the most adopted lean manufacturing practices. Kaizen and total productive maintenance followed respectively. And finally the least implemented lean manufacturing practice according to respondents was value stream mapping.

The Effect of Lean Manufacturing on Operational Performance

The respondents strongly agreed that adoption of lean manufacturing practices has a positive effect on operational performance, through improved features in product quality, increased product customization, reduced set-up time, speedy delivery of consumer orders and reduced manufacturing costs.

From the regression analysis, there's a positive relationship between JIT, continuous improvement/kaizen, value stream mapping (VSM), and total product maintenance (TPM) and operational performance. It nonetheless showed a negative relationship between automation/jidoka and operational performance.

Challenges of Adopting Lean Manufacturing Practices

High cost of implementation was seen as the most prevalent challenge in adopting lean manufacturing practices and failure to implement lean into the supply chain. There was wrong implementation sequence and resistance to change respectively. Customer dissatisfaction as well as lack of top management support challenges were ranked among the least faced difficulties of LM adoption.

Information relating to lean manufacturing practices is difficult to get as it is a sensitive and competitive area.

Conclusions

Lean manufacturing is the new paradigm that manufacturing firms are adopting to stay competitive in the globalized market. Lean manufacturing practices; just-in-time, continuous improvement, total productive maintenance, jidoka and value stream mapping had been widely adopted by firms in Mombasa County. The effect of lean manufacturing practices on operational performance was positive and leads to improvement in the operational performance of manufacturing firms. This indicates that, if manufacturing firms in Mombasa County adopt lean manufacturing practices they would enhance their product quality, reduce delivery and lead time, increase flexibility and significantly reduce their manufacturing costs. The lean manufacturing practice that negatively affected operational performance was automation/jidoka and thus it was established that there is a strong positive relationship between JIT variable, continuous improvement variable, total productive maintenance variable, value stream mapping variable and operational performance variable.

Lean manufacturing practices may not the only variable that influences business success because all the equations confirm that in the absence of LM practices there could be improvement in operational performance. Manufacturing firms should adopt LM practices to better and continually improve their operational performance in order sustains a moderate business position (Agus & Iteng, 2013 Management can use the results to develop growth strategies for their companies. However, the direction of the relationship needs to be ascertained by conducting large-scale empirical studies.

Recommendations

Manufacturing firms should adopt lean manufacturing practices namely JIT, kaizen, jidoka, VSM and TPM in order to improve their operational performance and reduce automation pratice. There is also need to educate the employees on what lean manufacturing is therefore training on the concept is recommended.

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