

An Assessment of the Lean Deployment in the Mauritian Textile Industry.

Keshav Ramgoolam

School of Business, Management and Finance
University of Technology, Mauritius
La Tour Koenig, Mauritius.
keshavramgoolam99@gmail.com

Needesh Ramphul

School of Business, Management and Finance
University of Technology, Mauritius
La Tour Koenig, Mauritius.
needesh.r@umail.utm.ac.mu

Abstract

Lean Manufacturing is a century old concept, initially developed by the Toyota Company. The word lean is ubiquitous but it can be diversely explained. The most common definition of lean is to be highly responsive to customer demand by reducing waste. The word Lean Manufacturing is synonymous with Agile Manufacturing, Just-In-Time or the Toyota Production System. The primary aim of Lean is to reduce waste from the Value Stream of an organization and according to the pioneer of Lean, Taiichi Ohno, waste can be categorized into seven categories. Through the elimination of waste, lean manufacturing helps in increasing productivity, improving quality, as well as reduction of cycle time, all of which contribute to improved profitability of the institution. The aims of this study are to use Lean methodologies to improve productivity through multi-skilling of operations, reduce waste from the value stream and decrease the dynamic cycle time, improve quality and reduce defects. Through the survey questionnaire, the value streams of the Mauritian Textile Industries were analyzed for non-value-added activities, and these wastes were subsequently reduced from the process. The main gains of this study were to help the Mauritian Textile companies gain competitive advantage and survive in this tough market.

Keywords

Lean, Lean Manufacturing, Waste, Productivity, Value Stream.

1. Introduction

1.1 The Need for Survival in the Textile Industry

In this twenty-first century, there is fierce competition for survival in the manufacturing sector. While it is one of the fastest growing industries in the world, it is also one in which many organizations are struggling in the customer driven and globally competitive markets. Many institutions have struggled because of their lack of understanding of the changed mind-sets of the customers and the new cost practices. The challenges faced by numerous manufacturing organizations are how to remain competitive and sustain their market share whilst simultaneously overcoming the rising production cost and variations in the product mix.

Almost all textile industrialists are facing a dilemma; either to adapt to change or to resist the change and face the threat of becoming extinct. Back in the early nineties, the apparel industry adapted to change by transferring their production operations to under developed countries, with the main rationale behind this move being the cheap labor. But, with development, the cost of labor has been steadily increasing and the industry has had to look towards new solutions. While there are several trade agreements which benefit the industries such as the Africa Growth and Opportunity Act (AGOA), these trade agreements only partly cover the increased expense of industrialists.

One of the most sought-after solutions to those suffering industries, for them to overcome the challenges they are facing, is the Lean Manufacturing (LM). Lean seems to be the logical choice because LM's goal is to be highly responsive to customer demand, to produce goods in shorter lead times and by generating less waste which will, in turn, maximize productivity and profitability of the manufacturing firm. The Lean concept first originated from the Toyota Manufacturing System (TPS) in the early nineteenth century.

Back then, to compete against the American and German car makers, the Japanese car maker Toyota, developed this philosophy. And to this day, Toyota – the number one car maker in the world - is the living proof that Lean Manufacturing is the solution to maintain competitiveness in the market. By using less inventory, less human effort, less investments, as well as a reduction in number of defects, Lean Manufacturing gives the organizations a competitive edge over their competitors.

While initially, this philosophy was instilled for the mass production of Motor Vehicles, many other manufacturing firms are now resorting to using the same concept to boost their productivity while lowering their production costs. One such industry which has adopted the Lean Manufacturing is the Textile Sector. The textile industry is probably among the most competitive one, mainly because customer demand is increasing every instance that influences the speed of the delivery, quality and cost, which plays a vital role in the present global market. An important factor which impacts on the textile manufacturing industry is that the latter has to continuously strive for simultaneous improvements in terms of quality and productivity.

Lean Manufacturing is not a magical solution and it has been known that certain organizations could not successfully implement lean in their process. The common reason behind their failure is that many Process Industries, such as the Textile Industry, resort to using automated machines for bulk production and the latter seldom offer flexibility in the process. It is the nature of the apparel industry that makes it a challenge for the successful implementation of Lean. (Saleeshya & Raghuram, 2012)

However, LM has several paybacks. Lean Manufacturing is one of the methodologies to achieve world class manufacturing in the organization through a cost reduction mechanism. Lean Manufacturing contains several universal management principles and tools, meaning that it is very flexible, and can be implemented in almost any organization. Amongst the numerous benefits of using Lean manufacturing in the textile industry, improving productivity, reduced cycle time and elimination of wastes, and improved quality are the most key ones. Lean Manufacturing enables the apparel makers to manufacture their products with high efficiency and quality as well as fulfil the customer requirements in the shortest span of time possible.

1.2 Problem Statement

The Mauritian Textile Industry is in dire need for survival in the market. Due to the rising production costs, the impending legislative barring expatriates to work for over 5 years, as well as the stiff competition from low cost countries, the Mauritian Textile Industry has to change its process and adapt to the lean methodology or face extinction. This research will help in identifying some of the wastes in the company's manufacturing process by carrying out value stream mapping – this involves the identification of non-value-added processes in the production and will also help in improving the quality as well as productivity of the textile industry. Through lean, productivity can be improved by increasing output and by decreasing the time taken to produce the garment.

Traditional apparel manufacturing resorts to using the Progressive Bundling System (PBS) – the main disadvantage of which is the high Work-In-Progress (WIP). Simultaneously with the high WIP, throughput time as well as repair time will subsequently increase – which will contribute to the ineffectiveness of the process. Lean Manufacturing, on the other hand, uses a Single Piece Continuous Flow (SPCF) which tackles the main drawbacks of the PBS. As its name suggests, the SPCF focuses on production using one piece at a time – one of the main benefits of this is that it considerably improves the throughput time and also improves on the quality. By using the Single Piece System, it gives another advantage to the production line, namely the ability to become more flexible and adapt quickly to style changes. Previously, the Mauritian Textile Industry used to get big, yet simple styled orders. But now, they get smaller orders, with more complicated styling which explains the benefit of Lean Manufacturing to the production lines. Together with SPCF, another benefit of Lean Manufacturing is that it instils Built-In-Quality (BIQ) mind-set to the worker.

To maintain competitiveness, as well as decrease the cycle time, Lean Manufacturing will be essential for the Mauritian Textile Industry. Not only does the Mauritian Textile Industry aim to improve the value-added processes, but it also plans on capacity expansion without the purchase of additional factories.

1.3 Aims & Objectives of Study

The purposes of this study are to use Lean methodologies to:

1. Improve Productivity through multi-skilling of operations,
2. Reduce waste (Non-Value-Added activities) from the Value Stream and decrease dynamic cycle time,
3. Improve Quality and reduce Defects.

Lean manufacturing is a systematic approach to identifying and eliminating wastes through continuous improvement by conveying the product at the pull of the customer in pursuit of production. Since lean manufacturing eliminates many of the problems associated with poor production scheduling and line balancing, lean manufacturing is particularly appropriate for companies that do not have Enterprise Resource Planning (ERP) systems in place or do not have strong material requirements planning (MRP), production scheduling, or production allocation systems in place.

2. Literature Review

2.1 Definition of Lean Manufacturing

The word “Lean Manufacturing” is ubiquitous, but it can be explained diversely. Lean Manufacturing has numerous definitions, some of which are listed below:

“The goal of LM is to be highly responsive to customer demand by reducing waste. LM aims at producing products and services at the lowest cost and as fast as required by the customer”. (Bhamu and Sangwan, 2014)

A Lean manufacturing philosophy requires respect for people, continuous improvement, a long-term view, a level of patience, a focus on process and an ability to understand where the individual is in his or her development (Ahmad and Azuan, 2013).

The goal of the Lean manufacturing system is doing more with less time, space, human effort while giving the customer what they want in a highly economical manner (Paranitharan et al, 2011).

Yet, the most suitable definition, in this context, is according to the book *The Machine that Changed the World* (Womack et al, 1990), which states that the term Lean represents “a system that utilizes fewer inputs in order to create the same outputs than those created by a traditional mass production system, while increasing the range of different finished goods for the end customer.”

From the above definitions, Lean can also be described as a philosophy that combines a cluster of tools and techniques into the business processes, with the aim of optimizing the cycle time, the human resources, and improving productivity by instilling a high-quality level in the products being manufactured. Lean has simplistic principles and its practices have been developed over almost a century. While the principles have maintained their originality, the practices have evolved over time – through trial and error. For a company to implement lean, it will require commitment from the whole work-force, not only production people or management people. Unless the organization, as a whole, decides on adopting the lean methodology, success of this philosophy is hard to attain.

2.2 Origins of Lean & the Toyota Production System

The roots of the Lean concept can be traced back to Japan in the early nineteenth century – namely at the Toyota Motor Company. After World War II, Japanese manufacturers were facing the dilemma of insufficiency of materials, financial problems, and human resources. (Thanki and Thakkar, 2014) In order to compete with the US and the German car manufacturers, Toyota developed its own production system, the world renowned Toyota Production System, with at its helm, 4 prominent Japanese persons who have contributed to its huge success in the manufacturing sector – Sakichi Toyoda, the founder of the Toyoda group in 1902; Kiichiro Toyoda, the son of Sakichi who was at the head of the automobile manufacturing operations between 1936 and 1950; Eiji Toyoda, the Managing Director of the company between 1950 and 1994, and finally Taiichi Ohno – the father of the Kanban System. (Shah et al, 2007)

“The Toyota production system has been created on the practice and evolution of one very useful technique that reduces cost and time while challenges every activity in the value stream” (Ohno, 1988). The technique is more commonly known as the “Five Whys” Methodology. The master minds behind this methodology believed that by constantly asking why after each answer, it is much easier to reach to the root cause of an issue, which in turn, assists in successful alteration of a problem. The Kanban system, developed by Ohno, implemented the concepts of Just-In-Time and Autonomation. “A Kanban is a tool to achieve just-in-time. It consists of a card containing all the information

that is required to be done on a product at each stage along its path to completion and which parts are needed at subsequent processes.” (Jasti and Kodali, 2016 & Monden, 1993)

Ohno’s system “emphasized low cost production through the elimination of waste in the system” (Bhamu et al, 2014 & Ohno, 1988), “whereas automation – automation with a human touch – recognized workers’ diligence and ability; and therefore, entrusted them with greater responsibility and authority” (Sugimori et al, 1977).

His approach focused on “achieving higher profitability by reduction costs, rather than the traditional approach of increasing price to increase profitability” (Dennis, 2007). The Toyota Production System aimed to improve profits, thereby giving customers better quality products for the same prices.

2.3 Aims of Lean Manufacturing

Liker (1996) stated that “Lean Manufacturing is an operational strategy oriented toward achieving the shortest possible cycle time by eliminating waste”. Lean Manufacturing aims to minimize and eradicate wastes from the value stream and reducing the dynamic cycle time while simultaneously maximizing productivity and improving quality.

2.4 Value Stream

The process of transforming raw material into finished goods is the objective of any manufacturing company. The value stream can be referred to all operations and processes that are involved in the transformation of raw materials into finished goods, and this value stream can be further sub-divided into 2 groups: Value Added (VA) and Non-Value Added (NVA). The Lean Manufacturing methodology focuses on the removal of non-value-added process, which directly results in reducing the time being an order is placed to the order being shipped or delivered to the customer. Value stream management is one core aspect of the Toyota Production System – it is “a management tool for planning a production process, involving lean initiative through systematic data capture and analysis” (Jasti et al, 2014).

2.5 MUDA – the 7 Wastes associated with Lean Manufacturing

According to Tapping (2002) “the ultimate lean target is the total elimination of waste. Waste, or Muda, is anything that adds cost to the product without adding value”. In any process, there are usually many wastes; in Lean, the word “Muda” – the Japanese word for “Seven wastes” - is very common. Taiichi Ohno was the original developer of the “Muda” concept. According to him, the 7 Wastes can be classified under the acronym *TIMWOOD*:

T: Transportation – unnecessary movement of materials, I: Inventory – excess stock of raw materials or semi-finished goods (Work in Progress), M: Motion – any unnecessary motion in carrying out a process, W: Waiting – idle time between processes, O: Over Processing – Doing more to the product than required by customer, O: Over Production – Producing products that are neither intended for inventory nor sale, D: Defects – defective products that require rework or replacement

2.6 Key Characteristics of Lean Manufacturing

2.6.1 Operational Stability & Continuous Flow

Operational stability is the very foundation of a lean organization. Very often it is associated with continuous flow. In a manufacturing organization, the continual flow of products is essential to avoid bottle necks which directly cause losses in productivity. While continuous flow was important for the implementation of lean, nowadays, many manufacturing organizations are resorting to one piece flow to make the process more reliable.

2.6.2 Total Quality Management

Another key pillar of the Lean Manufacturing is Total Quality Management. Under the Total Quality Management, Built-in Quality, Cause & Effect (Fish Bone) Diagrams, Pareto Charts, and even “Five Whys” are used to ensure highest quality of the products from the manufacturing organization. Statistical Process Control (SPC) and Six Sigma are common quality management programs that manufacturing organizations use to ensure that the highest quality standards are achieved. Continuous improvement is synchronous with Total Quality Management.

Furthermore, customer involvement, cross-functional product design, and quality function deployment are all practices and principles that are designed to manufacture high quality goods in an efficient manner with respect to customer specification and desire.

2.6.3 Visual Management & Five S

According to (Levinson 2002), “an automated workstation can announce problems using a visual or auditory signal which cues the operator to fix and restart it”. “The five types of visual control systems that are frequently used are call lights and an Andon board; standard operations sheets; Kanban tickets; digital display panels; and store and stock indicator plates” (Jasti et al, 2016, & Monden, 1993).

A second Japanese concept, known as the 5S culture is part & parcel of lean manufacturing. This 5S culture deals more with the housekeeping side of a manufacturing organization. 5S comes from the Japanese words Seiri which means Clearing up, Seiton which can be translated to Arranging, Seiso which is known as Neatness, Shitsuke which can be referred to Discipline, and Seitkitsu which means Continuous improvement. The focus of the 5S is to enable an organization to systematically enhance visual management, promote cleanliness and standardization which directly results in a more effective & productive process and usually a safer work environment. Lean manufacturing advocates adoption of 5-S for eliminating delays by maintaining good housekeeping facility as it helps in choosing the right tool without delay (Sharma et al, 2016).

2.6.4 Kaizen

Asaaki Imai (1986) defines Kaizen as “improvement or continuous improvement in social life, home life, personal life and working life. Kaizen aims to continuously improve the production process by eliminating the Non-Value-Adding factors from the production methods. (Arya and Choudhary, 2015) Kaizen is a Japanese word meaning ‘gradual and orderly continuous improvement’ or ‘change for the better’. One of the major requirements of implementing the Kaizen business strategy is that the manufacturing organization needs the involvement of everyone in the organization, that is all the personnel must be working together to make improvements without large capital investments. Kaizen is a culture of sustained continuous improvement focusing on elimination of all wastes in the manufacturing processes.

2.7 Application of Lean Manufacturing in the Textile Industry

The textile industry is probably the one, after the automobile industry, to benefit the most from the lean concept. These ‘waste processes’ have been identified while following the lean concept. Nowadays, to gain competitive advantage and retain the market share, while meeting with the challenges of rising production costs, Lean Manufacturing is being resorted to by Textile firms. Dynamic cycle time reduction, head count savings, maximizing productivity, and increasing efficiency are just few of the targets that have been set by the textile organizations for their survival. Through the use of Lean Manufacturing, and by considering the principles of the Toyota Production System, there is scope for improvement in the textile manufacturing industries.

Computer Integrated Manufacturing (CIM) is synchronous with LM for a textile industry, in the sense that it extensively makes uses of Information Technology to aid production through the design of products, planning of production, controlling of operations as well as other important tasks such as use for communication purposes. CIM incorporates several stand-alone applications such as Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM) as well as Manufacturing Resource Planning (MRP - II). The essential objective of CIM is to streamline the manufacturing processes and to integrate them with other business functions (such as accounting, financing, distributing, marketing) (Sharma et al, 2016).

3. Methodology

3.1 Research Objectives

There are several key objectives behind this research; primarily, the aim is to know how much the work-force knows about lean concepts, secondly, to understand the factors that are affecting people to adopt lean manufacturing, and thirdly, to assess the benefits of Lean Manufacturing for the organization’s value stream.

3.2 Research Questions

Several questions were raised:

1. Does lean improve productivity at work?
2. What is the major benefit of lean manufacturing in the value stream of a company?
3. Does lean influence Quality and Dynamic Cycle time?

These questions will aid in the selected research approach, and a research strategy will be chosen accordingly.

3.3 Formulation of Research Hypothesis

1st Hypothesis: H₁: Lean Manufacturing helps in improving productivity, and subsequently, efficiency through multi-skilling of operations.

H₀: Lean Manufacturing does not help in improving productivity, nor efficiency through multi-skilling of operations.

2nd Hypothesis: H₂: Lean Manufacturing helps in eliminating Non-Value-Added Activities (Waste) and reduces Dynamic Cycle Time.

H₀: Lean Manufacturing does not help in eliminating Non-Value-Added Activities (Waste) and does not reduce Dynamic Cycle Time.

3rd Hypothesis: H₃: Lean Manufacturing improves Quality and reduces defects.

H₀: Lean Manufacturing does not improve Quality nor reduces defects.

3.4 Research Methodology

For this project, Quantitative research was used. Literature Research was initially used to gain an understanding of the underlying concepts of Lean Manufacturing. Quantitative analysis involved the analysis of raw data from the survey carried out. It helped in providing an insight into Lean Manufacturing and aided the formulation of several hypotheses. IBM's SPSS software was used to test interpret the data from the survey. To measure the consistency of the data obtained from the survey, Cronbach's alpha test was used to test the reliability of the information obtained.

3.5 Sample Size

Since the sample population of respondents in the Mauritian Textile Industry is two hundred and eighteen (218), the Slovin Formula was used to calculate the sample size with a 5% margin of error since the author wanted a confidence level of 95%. Since the sample size is being used rather than the population itself, there is an allowable margin of error in the calculation.

Sample size was calculated thus:

$$n = \frac{N}{1 + NE^2}$$

Where n= Sample Size, N = Population Size, E = Margin of Error

$$n = \frac{218}{1 + (218)(0.05)^2}$$

$$n = 141$$

Thus, the sample size was found to be equal to 141.

Since, in any study, the sample size should be representative of the sample population, and in this case, the sample population is only two hundred and eighteen, the author decided to use the sample size of one hundred and forty-one.

3.6 Survey Design (Questionnaire)

The primary objective of the survey was to the impact of lean on the personnel, the main benefits of lean (such as reduction in cycle time, improvement on quality) as well as the most common waste removed by resorting to LM. The survey was designed by the author to link up the interplay between theory and analysis.

4. Results & Discussion

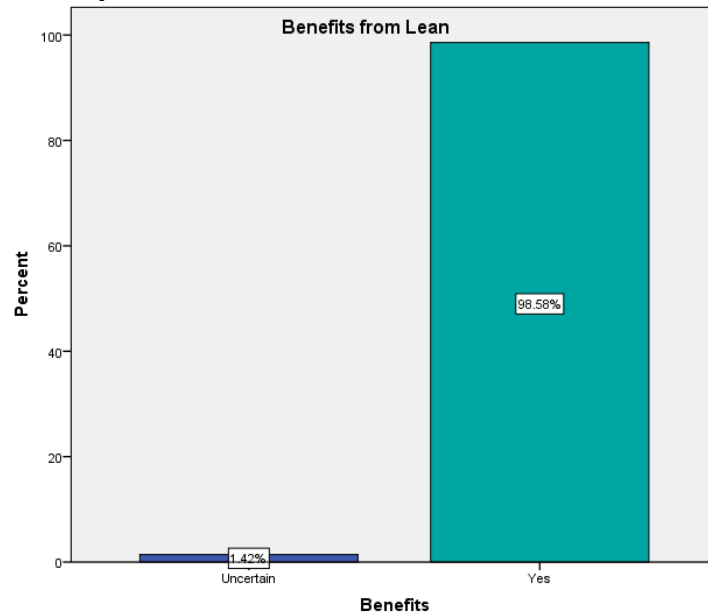
4.1 Results

This chapter serves the purpose of analyzing both the primary and secondary data, as well as validating the hypothesis stated in the previous chapter from the results obtained through SPSS.

4.2 Primary Data Analysis

In this dissertation, the author used the online survey tool, Lime Survey, to collect information from the respondents. This software was used because the entire group of respondents was within the same industry and the Lime Survey software was made accessible through the internet and the concerned respondents already possessed a desktop computer. The response rate for the survey questionnaire is 100%. To analyze data from Lime Survey, IBM's Statistical Package for Social Sciences (SPSS) was used. From the data collected, the following bar charts were made.

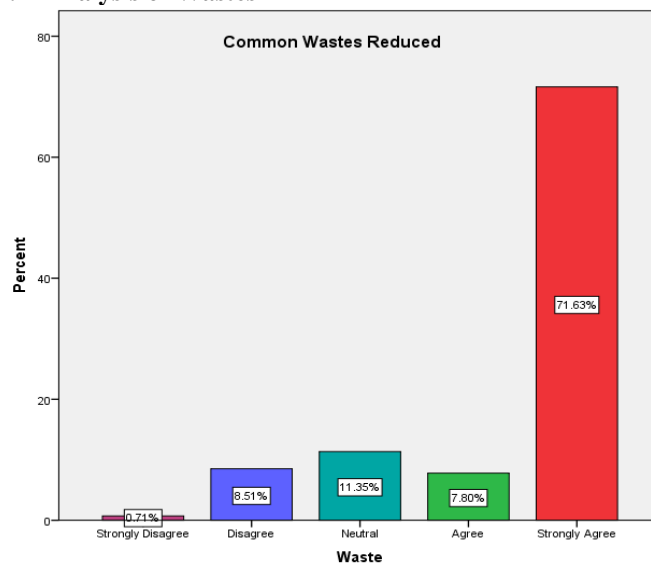
4.3 Analysis of LM Benefits



Almost 99% of the respondents agree to the fact that Lean contributes to the industry's benefit. The remaining 1% is uncertain to whether LM will be beneficial to the organization. This 1% could be the new recruits who are yet to see the improvements from Lean. With reference to Bhamu and Sangwan (2014), LM proves beneficial to the company by "producing products and services at the lowest cost and as fast as required by the customer." The benefits will be to reduce its operational cost while providing the high-quality garments at the fastest possible time.

Figure 1: Response to whether LM contributes to organization's benefits

4.4 Analysis of Wastes



The respondents were asked if Lean helps in identification and reduction of waste. Almost 80% of the respondents agree that Lean indeed reduces waste from the value stream of the company with 11% being neutral in their choice and the remaining minority of 9% disagreeing with the reduction in waste. Again, the logical explanation will be that these people maybe the back-room staff of the production departments, and through coaching, these people can indeed notice the reduction in waste. Bhamu and Sangwan, (2014) said that "The goal of LM is to be highly responsive to customer demand by reducing waste." This argument is supported by the majority's response that lean helps in reduction of waste.

Figure 2: Reduction in Waste

4.5 Analysis of Improvement in Productivity

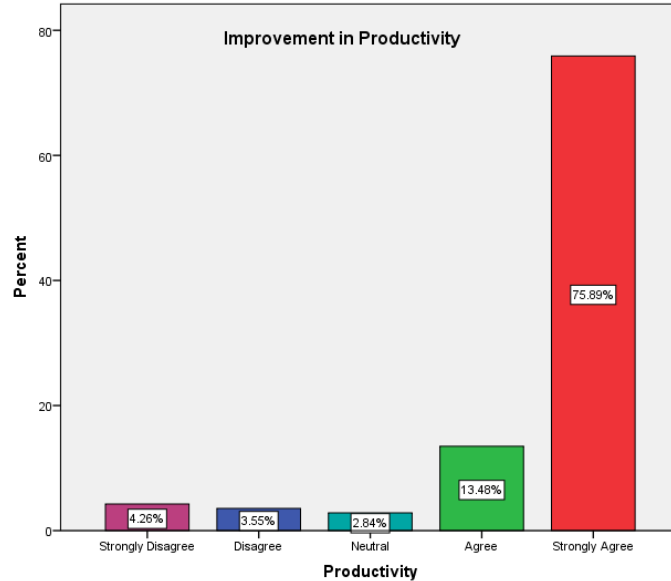


Figure 3: Improvement of Productivity

The respondents were asked if they believed that LM helped in improving productivity. As per the above representation, almost 90% of the respondents agree that LM contributed to an improvement in productivity. Around 7% disagree with the remaining respondents being neutral in their choice. The 7% who disagreed could be those people with no direct exposure to productivity, such as a production clerk doing advanced preparation in terms of paper works, and not dealing directly with production. If exposed directly to production, it is expected that they will agree to the improvement. Jasti and Kodali (2014) stated that LM have helped improved not only productivity but also in terms of quality in numerous industries. 90% of the respondents agreed to this statement.

4.6 Analysis of Improvement in Cycle Time

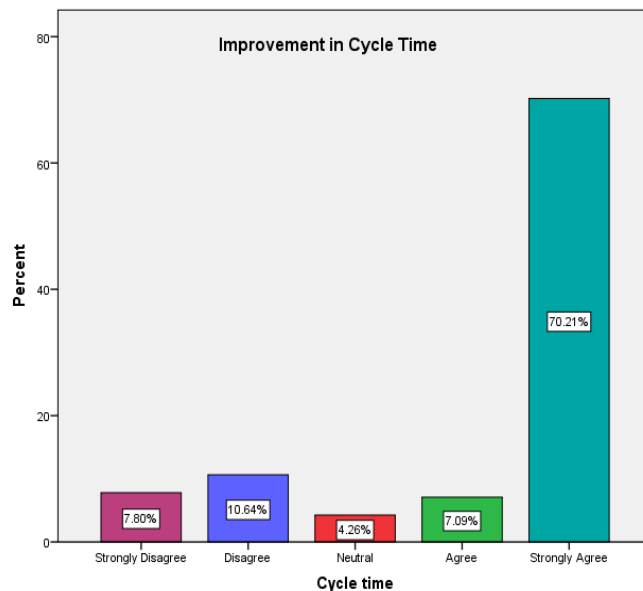


Figure 4: Improvement of Cycle time

One question in the survey asked the respondents whether they believed that lean helped in reducing the cycle time. Above 77% of the respondents agree to this, 18% disagreed with the improvement in cycle time, while the minority were uncertain that Lean helps in decreasing the cycle time. Many people are not bothered with cycle time, they just work to ensure that the complete the operations in the department. This could explain why quite a large portion of respondents did not agree to cycle time improvement. Liker (1996) stated that “LM is an operational strategy oriented toward achieving the shortest possible cycle time by eliminating waste”. The vast majority of respondents agree that indeed LM help in decreasing the cycle time.

4.7 Analysis of Improvement in Quality

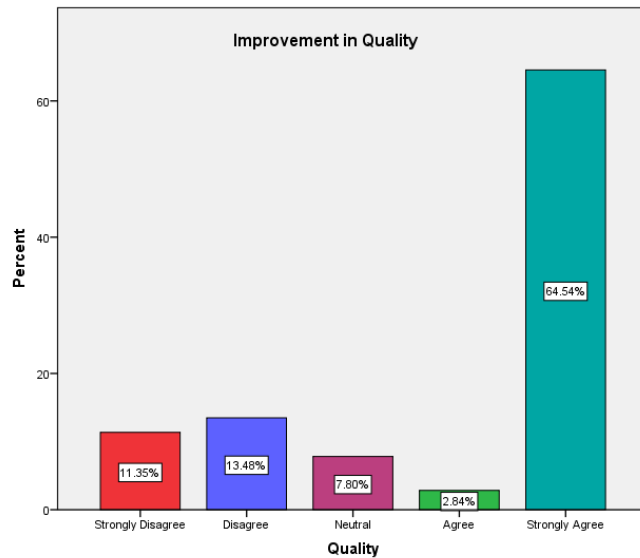


Figure 5: Improvement of Quality

The respondents were asked if they believed that, after starting the lean journey, there was any improvement in quality. 67% of the respondents agreed that Quality has improved while around 24% did not agree, and the remaining 2% was not sure whether quality has improved since inception of LM. The 24% who disagreed could be those people who do not deal with quality in terms of garments, example a production clerk preparing a packing list. Mainly, those who are not directly involved with the garments will not agree to the improvement in quality. Since its inception, Ohno's system (lean manufacturing) "emphasized low cost production through the elimination of waste in the system." (Ohno, 1988) The results from the survey agree with Ohno.

4.8 Analysis of Benefits of LM

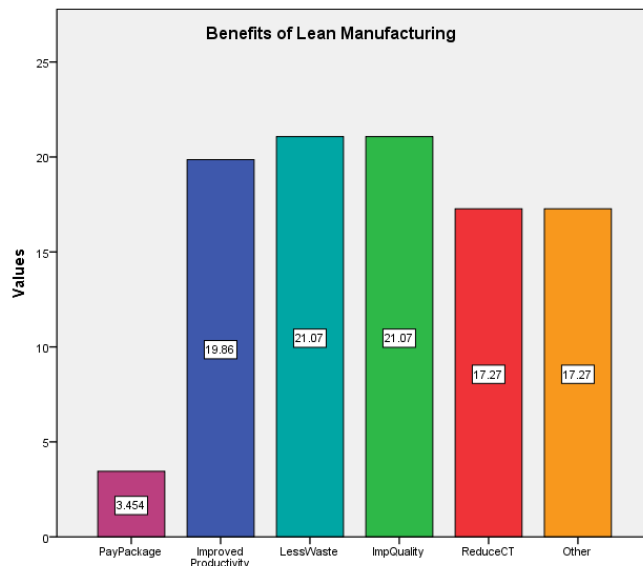


Figure 6: Benefits of LM

Regarding the benefits of lean, the respondents were given 7 choices to select their most favored benefit. The majority of 42% selected "Improved Quality of garments" and "less waste in the value stream", 20% chose "improved productivity of the organization", 35% preferred "Reduced cycle time of operations" and "others", and 3 people selected "employee morale has improved with better pay package". Empirical reviews by Bhamu and Sangwan (2014), Ahmad and Azuan (2013), as well as Womack et al (1990) amongst others, all elaborate on the main benefits of lean which are: Improve Quality, Reduce Waste, Improve Productivity, and Decrease the Cycle Time of operations. The respondents of the survey agree to literature by selecting the same choices given.

4.9 Variable Analysis, Reliability and Significance

SPSS produces two Sig. values with the first one being the Kolmogorov-Smirnov Test, and the other being the Shapiro-Wilk's Test. Usually, for a sample size greater than 50, the Kolmogorov-Smirnov Test is favored, which is the case for this dissertation. Since the number of respondents is 141, which is more than 50, the Kolmogorov-Smirnov test is used.

H₁: Lean Manufacturing helps in improving productivity, and subsequently, efficiency through multi-skilling of operations.

For the first Normality test, productivity was cross tabulated with multi-skilling. Since the Sig. value is less than 0.05, this means that data is not normally distributed. Thus, a variety of tests can be used to determine the relationship between productivity and multi-skilling. The tests used were: Pearson Chi-Square Test, and Phi & Cramer's V Test since the variables used in SPSS were in the nominal scale. The Pearson Chi square test is used to test whether a statistically significant relationship exists between two categorical variables. Throughout the Chi Square Test, the following three conditions were respected:

1. The variables were categorical, 2. There was at least a total of 30 observations in the table & 3. Each cell contained a count of 5 or more.

Table 1: Normality & Chi-Square for first Hypothesis

Tests of Normality					Chi-Square Tests						
	Multi Skilling	Kolmogorov-Smirnov ^a			Shapiro-Wilk				Value	df	Asymp. Sig. (2-sided)
		Statistic	df	Sig.	Statistic	df	Sig.				
Productivity	Strongly Disagree	.469	22	.000	.452	22	.000	Pearson Chi-Square	22.755 ^a	16	.000
	Disagree	.377	21	.000	.629	21	.000	Likelihood Ratio	24.667	16	.000
	Neutral	.506	15	.000	.421	15	.000	Linear-by-Linear Association	.095	1	.000
	Agree	.365	8	.002	.724	8	.004	N of Valid Cases	141		
	Strongly Agree	.509	75	.000	.365	75	.000	Symmetric Measures			
									Value	Approx. Sig.	
Nominal by Phi								.402	.000		
Nominal Cramer's V								.201	.000		
N of Valid Cases								141			

a. Lilliefors Significance Correction

From the above tables, the results revealed a Chi-Square value of 22.755, with a p-value of 0.000, which is less than the significant level, α , 0.05. There is a strong evidence against the null hypothesis, thus validating the hypothesis, H₁. This indicates a significant relationship between the two variables examined. Moreover, the appropriate measure of correlation 0.402, with a Phi value of 0.000 indicating a significant correlation between productivity and multi-skilling.

H₂: Lean Manufacturing helps in eliminating Non-Value Added Activities (Waste) and reduces Dynamic Cycle Time.

For the second Normality test, waste was cross tabulated with cycle time.

Table 2: Normality & Chi-Square for second Hypothesis

Tests of Normality ^{b,c}								Chi-Square Tests			
	Cycle time	Kolmogorov-Smirnov ^a			Shapiro-Wilk				Value	df	Asymp. Sig. (2-sided)
		Statistic	df	Sig.	Statistic	df	Sig.				
Waste	Strongly Disagree	.528	11	.000	.345	11	.000	Pearson Chi-Square	18.779 ^a	16	.000
	Neutral	.492	6	.000	.496	6	.000	Likelihood Ratio	28.051	16	.000
	Strongly Agree	.374	99	.000	.705	99	.000	Linear-by-Linear Association	10.298	1	.001
								N of Valid Cases	141		
Symmetric Measures											
									Value		Approx. Sig.
	Nominal by Nominal	Phi							.365		.000
									Cramer's V	.182	
								N of Valid Cases	141		

a. Lilliefors Significance Correction

b. Waste is constant when Cycle time = Disagree. It has been omitted.

c. Waste is constant when Cycle time = Agree. It has been omitted.

From the above tables, the results revealed a Chi-Square value of 18.779, with a p-value of 0.000, which is less than the significant level, α , 0.05. There is a very strong evidence against the null hypothesis, thus validating the hypothesis, H₂. This indicates a significant relationship between the two variables examined. Moreover, the appropriate measure of correlation 0.365, with a Phi value of 0.000 indicating a significant correlation between waste

and cycle time. The Cramer V test obtained a value of 0.182 which shows that there is a relationship between these two variables.

H₃: Lean Manufacturing improves Quality and reduces defects.

For the third Normality test, quality was cross tabulated with defects reduced.

Table 3: Normality & Chi-Square for third Hypothesis

Tests of Normality							
	Defects Reduced	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Quality	Strongly Disagree	.267	11	.027	.817	11	.016
	Disagree	.238	14	.031	.817	14	.008
	Neutral	.362	14	.000	.728	14	.001
	Agree	.312	6	.069	.767	6	.029
	Strongly Agree	.460	96	.000	.566	96	.000

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	41.717 ^a	16	.000
Likelihood Ratio	36.901	16	.002
Linear-by-Linear Association	19.343	1	.000
N of Valid Cases	141		

Symmetric Measures		
	Value	Approx. Sig.
Nominal by Phi	.544	.000
Nominal Cramer's V	.272	.000
N of Valid Cases	141	

From the below tables, the results revealed a Chi-Square value of 41.717, with a p-value of 0.000, which is less than the significant level, α , 0.05. There is a very strong evidence against the null hypothesis, thus validating the hypothesis, H₃. This indicates a significant relationship between the two variables examined. Moreover, the appropriate measure of correlation 0.544, with a Phi value of 0.000 indicating a significant correlation between quality and defects reduced. The Cramer V test obtained a value of 0.272 which shows that there is a relationship between these two variables.

5. Conclusion & Recommendations

5.1 Conclusion

Lean Manufacturing was designed for the automobile sector and was developed by the Toyota Company more than a century ago. Lean concept has since evolved and now numerous sectors such as the textile sector is adopting its principles as they aim to maintain competitiveness and survive the market. The survey questionnaire was used to gather valuable information from the respondents and also helped in formulation of few hypotheses. From the data obtained, the author found out that in the textile factory, lean is very beneficial; it helps in improving productivity, elimination of waste from the value stream, reduction of the cycle time, and improvement in Quality.

5.2 Recommendations

Trainings should not be done within a training room, but rather it should be done on the Gemba, that is the workplace itself. The lean tools should be tailor made to suit a specific manufacturing operation and the personnel should be taught to actually use the lean tools as a means of improving their operations, rather than just using those tools for the sake of using them.

Multi-skilling is another key pillar to ensure that productivity is improved through lean. Continuous improvement is another pillar for the industry to adapt to the lean philosophy. The top management should aim to motivate its personnel such that the focus remains on Lean Manufacturing.

5.3 Future scope for Research

While Lean exists for over a century, it is still new in the Apparel Manufacturing Sector. Designed and perfected for the automobile sector, naturally it will require some modifications to prove its worth to the Textile Industry. Many Mauritian textile companies are in dire need for survival. Having previously resorted to foreign labor

as a means of maintaining low operational cost, now with new government legislations, the expatriate workers will be reduced and those textile companies should aim for localization. One scope for research is how can Lean help in recruitment of local workers. A second scope for research is how to extend the lean concept in the numerous Small and Medium Apparel Industries in the island for them to remain competitive and maintain profitability.

The Mauritian Textile Industry is seeking to use the lean philosophy as a means of gaining competitive advantage whilst simultaneously aiming to survive the market. Without a doubt, this is a challenge. But since lean has shown the proof with the automobile sector, there is reason to believe that a catered approach towards lean, will indeed help this textile company.

6.0 References

- Ahmad, S. and Azuan, S. (2013), "Culture and lean manufacturing: towards a holistic framework" Australian Journal of Basic and Applied Sciences, Vol. 7 No. 1.
- Amit Kumar Arya Suraj Choudhary, (2015), "Assessing the application of Kaizen principles in Indian small-scale industry", International Journal of Lean Six Sigma, Vol. 6 Iss 4 pp. 369 – 396.
- Dennis, P. (2002), *Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production System*, Productivity Press, New York, NY.
- Jaiprakash Bhamu Kuldip Singh Sangwan, (2014), "Lean manufacturing: literature review and research issues", International Journal of Operations & Production Management, Vol. 34 Iss 7 pp. 876 – 940.
- Liker, J.K. (1996), *Becoming Lean*, Productivity Press, Portland, OR.
- Liker, J. (2004), *The Toyota Way*, McGraw-Hill, New York, NY.
- Monden, Y. (1993), *The Toyota Management System*, Productivity Press, Portland, OR.
- Naga Vamsi Krishna Jasti Rambabu Kodali, (2016), "An empirical study for implementation of lean principles in Indian manufacturing industry", *Benchmarking: An International Journal*, Vol. 23 Iss 1 pp.183 – 207.
- Naga Vamsi Krishna Jasti Rambabu Kodali , (2014), "A literature review of empirical research methodology in lean manufacturing", *International Journal of Operations & Production Management*, Vol. 34 Iss 8 pp.1080 – 1122.
- Ohno, T. (1988) 'Dielectric ceramics', *HYBRIDS*, 4(3), pp. 10–16.
- Paranitharan, K.P., Begam, M.S., Abuthakeer, S.S. and Subha, M.V. (2011), "Redesigning an automotive assembly line through lean strategy", *International Journal of Lean Thinking*, Vol. 2 No. 2, pp. 1-14.
- S.J. Thanki Jitesh Thakkar, (2014), "Status of lean manufacturing practices in Indian industries and government initiatives", *Journal of Manufacturing Technology Management*, Vol. 25 Iss 5 pp. 655 – 675.
- Sugimori, Y., Kusunoki, K., Cho, F. and Uchikawa, S. (1977), "Toyota production system and Kanban system – materialization of just-in-time and respect-for-human system", *International Journal of Production Research*, Vol. 15 No. 6, pp. 553-64.
- Tapping, D., Luyster, T., & Shuker, T. (2002). *Value stream management: Eight steps to planning, mapping, and sustaining lean improvements*. New York, NY: Productivity Press.
- Vikram Sharma Amit Rai Dixit Mohd. Asim Qadri, (2016), "Modeling Lean implementation for manufacturing sector", *Journal of Modelling in Management*, Vol. 11 Iss 2 pp. 405 – 426.
- Womack, J., Jones, D. and Roos, D. (1990), *The Machine that Changed the World*, Harper Perennial, New York, NY.

Biography

Mr. Keshav Ramgoolam is a Production Engineer in a Mauritian Textile Company, with several years of experience in Lean Manufacturing. His company started its lean journey back in 2014 and he has since been a Lean master trainer for several departments. He is actively involved in industrial projects such as re-engineering the process to remove non value-added activities, improve productivity & quality and reduce cycle time. Furthermore, he often delivers trainings to the workforce to sensitize them about the benefits on lean. He recently published his dissertation in Lean Manufacturing for his Master in Business Administration Degree at the University of Technology, Mauritius. His areas of interest include chemical engineering, process engineering, lean management, environmental engineering, sustainability as well as total quality management. He is an Associate Member of the Institution of Chemical Engineers, UK (AMIChemE) and a fellow Member of the Institution of Engineering and Technology (MIET)

Mr. Needesh Ramphul is the Officer in Charge at the School of Business, Management and Finance at the University of Technology, Mauritius. He is a Lecturer in Management and Human Resource Management at the University of Technology, Mauritius. In addition to his academic background, he has already worked in the private sector as a manager and he has wide practical experience in the textile industry. He has also worked in the public sector for several years. He also provides consultancy services in designing management development programs for both the private and the public sector. His research interests include management development, performance management, operations management, Lean manufacturing, benchmarking, and human resource management.