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: H_1: Lean Manufacturing helps in improving productivity, and subsequently, efficiency through multi-skilling of operations.
H_0: Lean Manufacturing does not help in improving productivity, nor efficiency through multi-skilling of operations.
2nd Hypothesis: H_2: Lean Manufacturing helps in eliminating Non-Value-Added Activities (Waste) and reduces Dynamic Cycle Time.
H_0: Lean Manufacturing does not help in eliminating Non-Value-Added Activities (Waste) and does not reduce Dynamic Cycle Time.
3rd Hypothesis: H_3: Lean Manufacturing improves Quality and reduces defects.
H_0: 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

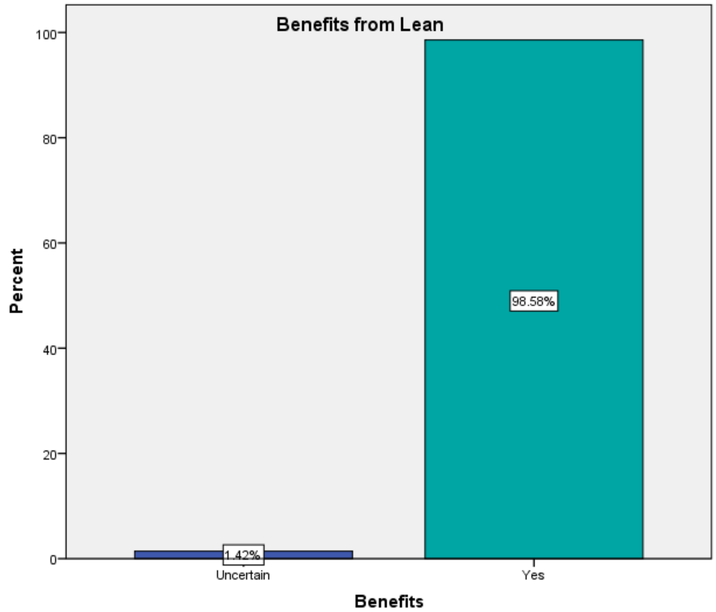
4.1 Results

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.

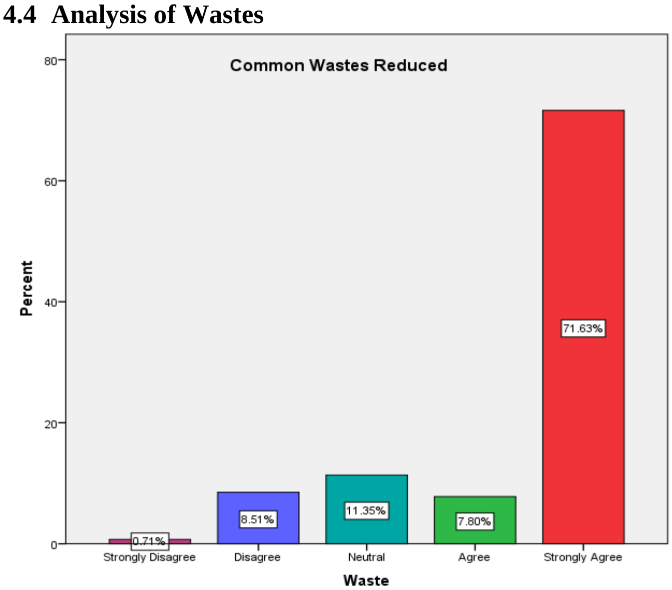
4.3 Analysis of LM Benefits



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

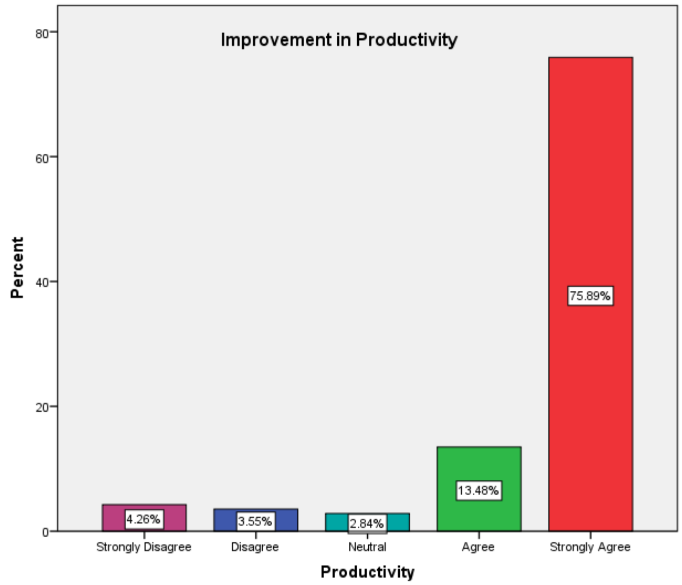


Figure 3: Improvement of Productivity

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

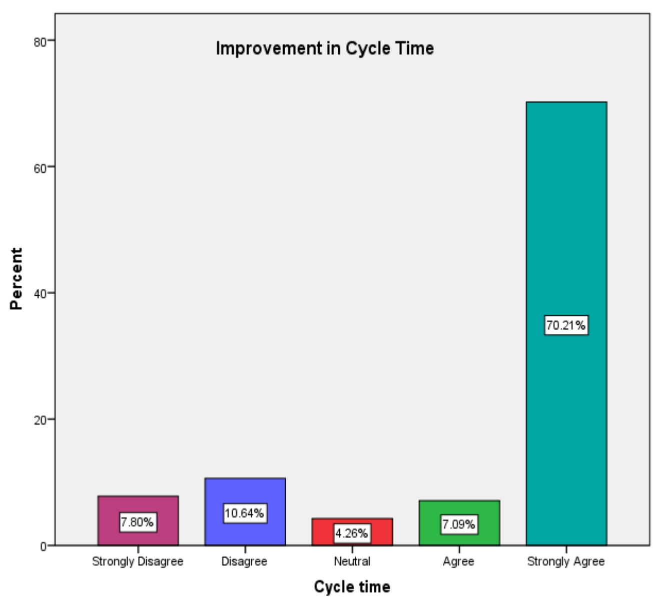


Figure 4: Improvement of Cycle time

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

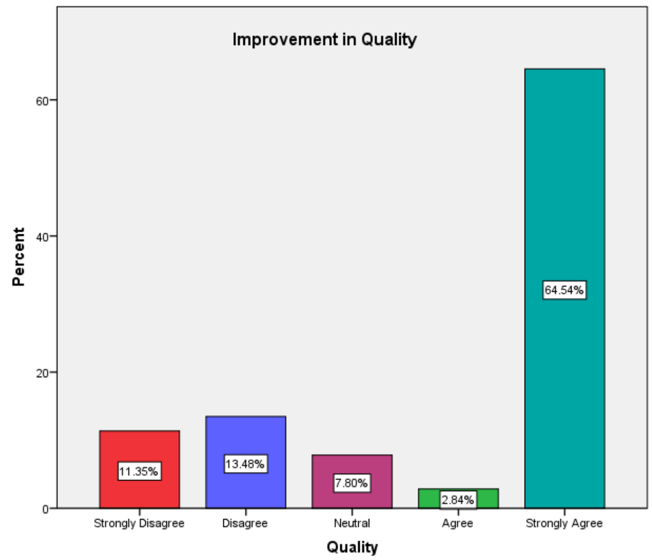


Figure 5: Improvement of Quality

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

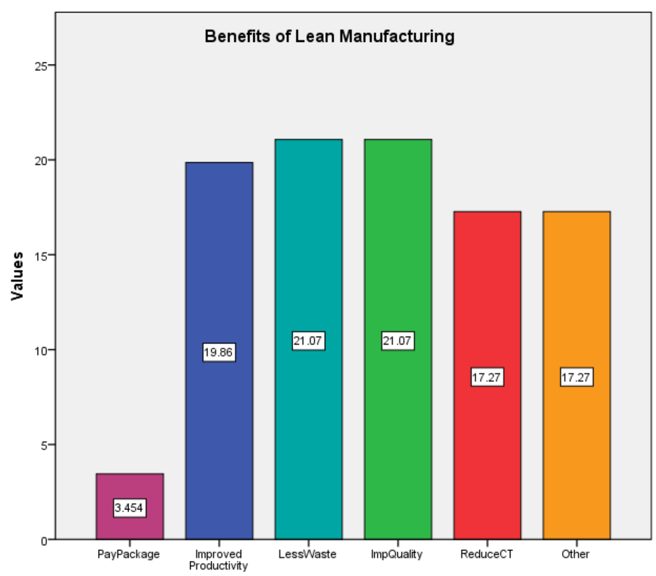


Figure 6: Benefits of LM

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.

H_1: 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

	Multi Skilling	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Productivity	Strongly Disagree	.469	22	.000	.452	22	.000
	Disagree	.377	21	.000	.629	21	.000
	Neutral	.506	15	.000	.421	15	.000
	Agree	.365	8	.002	.724	8	.004
	Strongly Agree	.509	75	.000	.365	75	.000

a. Lilliefors Significance Correction

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.755[a]	16	.000
Likelihood Ratio	24.667	16	.000
Linear-by-Linear Association	.095	1	.000
N of Valid Cases	141		

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.402	.000
	Cramer's V	.201	.000
N of Valid Cases		141	

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, H_1. 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.

H_2: 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]

	Cycle time	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Waste	Strongly Disagree	.528	11	.000	.345	11	.000
	Neutral	.492	6	.000	.496	6	.000
	Strongly Agree	.374	99	.000	.705	99	.000

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.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	18.779[a]	16	.000
Likelihood Ratio	28.051	16	.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	.000
N of Valid Cases		141	

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, H_2. 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.

H_3: 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 Nominal	Phi	.544	.000
	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, H_3. 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.

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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.