

**Assessment of Lean in Apparel Export Industry of National Capital Region (India)**

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**ABSTRACT**

*Timely and reliable measurement of manufacturing performance improvements after lean initiation in terms of Key Performance Indicators (KPI) not only enables the organization to evaluate the success of lean implementation, but, also to understand key areas for future improvements. Keeping the importance of using Key Performance Indicators (KPI), the present study was designed to comparatively assess the improvement in manufacturing performance among lean and non-lean initiated apparel units of National Capital Region (India) in terms of manufacturing key performance indicators -productivity, quality, work in progress and efficiency. The study was limited to 10 lean initiated and non -lean initiated apparel units each manufacturing the ladies garments in NCR. Apparel units in National Capital Region (NCR), India were selected using inclusion and exclusion criteria from the member list of Apparel Export Promotion Council, Gurgaon, India. A common full sleeve collar ladies top or shirt style was selected for this study. The Time Study Method was used to record the time taken to accomplish various operations involved in manufacturing of the selected common garment. Data was collected for all production days of the chosen design style. The result revealed that the lean initiated apparel export firms had higher operator productivity, total labor productivity and efficiency than the non- lean initiated units. Defect per hundred units and percentage defective in the lean initiated units were found significantly lower than the non- lean initiated units except for work in progress. Year of lean initiation was found to have significant difference in the performance of an apparel unit in the terms of efficiency and quality except for the productivity and work in progress. The research aimed to bring about awareness regarding positive impact of implementation of lean as the ultimate solution which could drive the global apparel industry towards achieving business excellence in today's heightened cut throat competition in the global apparel sector.*

*Keywords: Lean performance improvement assessment, Key manufacturing performance indicators, productivity, efficiency, quality, work in progress*

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**Introduction**

*“In the Indian apparel sector, the gradual increase in operating and material*

*costs is putting strains on profits. Complexity of orders in terms of style variability and small order sizes require*

*production centers equipped flexible and quick response manufacturing practices. In this situation, application of lean could be a greatest weapon to make breakthrough towards maintaining the profitability and sustainability”.*

*Mr Amit Gugnani  
Senior Vice-President  
Technopak*

The Toyota Production System (TPS), was developed at Toyota Motor Company in the 1950 as a most efficient and innovative production technique based on the principle of teamwork, standardization, wastes removal, adding value to customers and continuous improvement for the manufacturing of the automobiles. This system traces its roots to an automatic loom invented by Sakichi Toyoda who is popularly known as ‘Father of Toyota group’. The loom not only automated the work that used to be performed manually, but also built the capability to make judgments into the machine itself. By eliminating both defective products and the associated wasteful practices, Sakichi succeeded in tremendously improving both productivity and work efficiency. It has been evolved through many years of trials and errors to improve. This system became known as the TPS, which laid the foundation of today’s’ Lean manufacturing. Presently, it has increasingly been applied by leading automobile, apparel and textile manufacturing companies throughout the world as these companies try to find ways to compete more effectively against competition.

Adoption of lean as a manufacturing discipline in any organization is the start of a long term journey, involving cultural change, huge profits, increased employee commitment and continuous improvements. With the beginning of the lean journey in an apparel and textile manufacturing unit, the questions regarding what and how to measure it become paramount. Without focusing on the proper key performance indicators (KPIs) and measurements of

current activities and visualization of the improvements in terms of figures, the unit is forced to rely upon its judgment about accurately predicting the success of their lean effort. This leads to de-motivation among employees and management, often leading to discontinuation of its journey of improvement using new manufacturing system. Hence, it is important for every lean initiated apparel unit to select the assessment criteria’s for evaluating the success of a lean implementation. Measurement and monitoring of lean transformation is essential, as without it, management of the unit’s lean progress becomes impossible, ultimately leading to failure like most performance systems. The performance management system should be tailored to the organization, but, some common key performance indicators can be used as a powerful signal to check whether the unit is on the correct lean journey path.

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At present, there are no fixed indicators used to measure the success or failure of new improvement systems accurately in the apparel and textile industry. As financial results lag behind operational improvements in lean implementations, it is very important to have right key indicators which could evaluate the performance effectiveness after lean initiation in an apparel unit.

Some common KPIs used in general by an apparel unit are productivity , operators efficiency, ratio of direct operators to indirect operators, Levels of defects per hundred units (DHUs), cost of production, lead time, plant efficiency, line efficiency ,work in progress, dock to dock, SQDMC (safety, quality, delivery, morale, and cost), labor productivity, through put time, floor space, workers used, labor utilization, retention time, processing time, line balancing, weekly delivery output and percentage of rework (Collyer ,2010; Gamage et al.,2012a; GTZ,n.d ;Spahija et al.,2012).

### **Objectives of the Study**

Keeping the importance of using key performance indicators to evaluate the

success of lean implementation in an organization and *establishing the baseline figures against a number of important areas*, this study was planned with following aims and objectives:

1. To compare the manufacturing performance in terms of manufacturing key performance indicators namely productivity, efficiency, quality, work in progress among lean initiated and non-lean initiated apparel units in NCR in India.
2. To find the effect of the year of lean initiation on the performance of the apparel units.

### Limitations of the study

The study was limited to 10 lean initiated and non-lean initiated apparel units

each manufacturing ladies garments in NCR. Performance improvement was limited to sewing section.

### Materials and Methods

#### Selection of locale

The study was confined to the apparel units in National Capital Region (NCR) in India. NCR is a very important hub of economic activity in the country and it encompasses the entire metropolitan area of National Capital Territory of Delhi as well as neighboring states of Haryana, Uttarakhand, Uttar Pradesh and Rajasthan. This cluster accounts for about 25 % share in the country's current apparel exports. Location of NCR in India is shown in Figure 1.

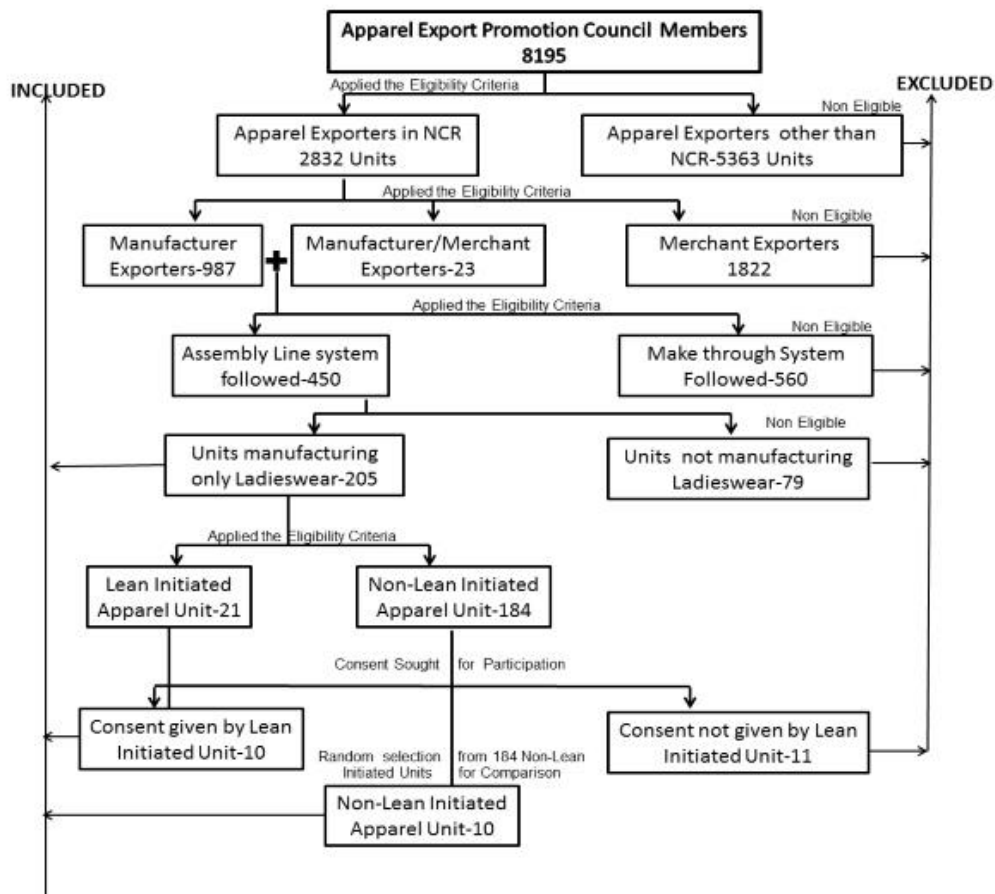


**Figure 1. Location of National Capital Region in India (from “CSR and Ethical Trading in India,” 2013)**

**Sample selection**

Ten lean initiated and non-lean initiated apparel units each were selected using inclusion or exclusion criteria from the member list of Apparel Export Promotion Council (AEPC),Gurgaon, India as shown in Figure 2. It was found that only 21 apparel units were practicing lean, and hence all of these apparel units were contacted through local associations like Okhla Garment Textile Cluster (OGTC) and Noida Garment manufacturing Association. Only 10 Lean initiated units agreed to provide the details and information required for the study, as well as allowed firsthand experience of lean implementation through personal visits to various departments of the apparel manufacturing units. For

comparison, 10 non- lean initiated apparel units were randomly selected using lottery method from the 184 non-lean initiated apparel units. Firstly, each apparel unit was assigned a unique number. These numbers were written on separate cards which were physically similar in shape, size, and color. They were put in the basket and thoroughly mixed and the slips were taken out randomly without looking at them. The small sample was considered appropriate for this study as most of the apparel units were not very willing to provide detailed information and data for investigation due to confidentiality and time constraint issues. Hence, cooperation offered and interest shown by them to participate was the main criterion to select the sample.



**Figure 2. Inclusion and exclusion method for selection of sample**

### *Selection of manufacturing key performance indicators*

In the present study, the impact of lean adoption on performance was determined by comparing 10 lean initiated and 10 non -lean initiated apparel units. Effective and reliable key manufacturing and environmental performance indicators were chosen, which had 5 key characteristics namely alignment with business, actionable and predictive, consistent, time trackable and peer comparisons (Khadem, Ali, & Seifoddini, 2008). Selection was also done keeping in mind the availability of data and the criteria through which effect of lean was more visible. Review of literature also helped in short listing the right indicators which could evaluate the performance effectiveness after lean initiation in an apparel unit (Blecha et al., 1993; Chakraborty & Paul,2011; Dalgobind & Anjani ,2009; Hodge et al., 2011; Johnson, n.d.; Jozaffe,2006; Karim & Rahman,2012; Paneru,2011; Perera & Perera,2012;Stotz, 2010).Further interaction with industrial engineering department personnel's and lean consultants helped in understanding the importance of key performance indicators (KPIs) which could sum up the results of the company's performance and help in their performance improvement in the future. Six main manufacturing KPIs selected were the operator productivity, total labor productivity, defect per hundred unit (DHU), defective percentage, work in progress (WIP) and line efficiency. These KPI's were capable of carrying out effective assessment quantifying the extent to which a process produces intended results.

A common full sleeve collar ladies top or shirt style was selected having a minimum order of 2000 pieces and the time study was conducted to calculate standard minute value (SMV) and standard allowed minutes (SAM). While conducting time study, 5 readings were noted for each element and average was taken as observed cycle time. Time study reading was eliminated in case of work stops due to electricity disturbance, non-availability of

raw material and machine breakdowns. The reason behind the selection of this garment was that it had many components which ensured that it had to go through all the processes in the organization. Moreover, literature review also supports the selection of top or shirt as a garment for this study as it is a most common garment to be manufactured by all garment manufacturers of NCR(Chakraborty & Paul,2011; Haque, Chakraborty, Hossain, Mondal & Islam,2012; Islam ,Khan & Islam,2013a;Islam , Khan & Uddin,2013b ; Kumar, Naidu & Ravindranath,2011;Ramesh , Prasad, & Srinivas,2008). Third eyesight (2010) also stated that t-shirts, tops and blouses form the 55% of the major products to be exported to other countries. For calculating single minute value, time study was conducted and standard allowed minutes (SAM) was calculated. Different formulae to calculate the variables used in the present research are given below.

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- *Productivity*- Productivity is the relationship between input and output. The output in garment factories can be in the form of pieces of finished garments in sewing section, meters of fabric inspected in inspection section, cut components in cutting section, or number of garments ironed in the ironing section, whereas the input of the sections or departments within the garment factory could be in the form of man-hours, machine hours, meters of fabric consumed or electricity consumed. In simple words it is concerned with the efficient utilization of resources in producing the goods.
  - Operator productivity  
=Output/Input(Ambastha,2012, p.32)  
Output= Achieved production in terms of number of garments  
Input=Number of sewing operators X Working hours/8/Number of working days
  - Total labor productivity=  
Output/Input

Input=Total labor X Working hours/8/Number of working days  
 Total labor =Number of sewing operators + Checkers +Helpers + Supervisors.

- *Efficiency*- It is the comparison of what is actually produced or performed with what can be achieved with the same consumption of resources (money, time, labor, etc.).Line efficiency is defined as “percentage utilization of available time”

Efficiency = SAM produced/Utilized minutes

SAM produced = Achieved production (Garment produced) X Standard minute value

Utilized minutes =Number of operators X Number of working hours

- *Work in Progress (WIP)*- WIP of garments is expressed in the number of pieces by simply recording daily production figures between each process and accumulating the difference between sequential processes (Gibson, 2008).

Work in progress in line = Total number of pieces in the line (pieces) =Total number of pieces unloaded from the line -Total number of pieces loaded (Ambastha, 2012, p.26)

- *Quality*.
  - Percentage defective level- It is the basic measure of quality percentage that most factories use at the end line and in the finishing department  
 Percentage defective level= Total defective garments/ Total garments inspected X 100
  - Defects per hundred units (DHU)- It is the ratio of number of defects per lot or sample, expressed in percentage.
  - Defects per hundred unit = Number of defects found/Number of units inspected X 100 (Ahsan, Hoossan & Efad, 2011; Ambastha, 2012, p.31).

## Research Instrument and Method

Field study visits were made to the selected apparel units to collect the technical information about the manufacturing processes, set up of machines and supporting devices at various levels.

The time study method was used to record the time taken to accomplish various operations involved in manufacturing of the common garment selected. The readings were taken five times on the time study sheet. Snap-Back method or repetitive or Fly-Back Method was used to measure the cycle time using stopwatch calibrated in seconds as advocated by Saurabh(1999,p.14). Basic time was calculated using the following formula.

Basic Time (Normal Time) = Observed Time (in minutes) X Observed Rating of the operator/ Standard Rating (100)

The standard time was later calculated by adding Process, Special, Personal Fatigue, and delay allowances appropriate to cover relaxation time using the formula given below.

SMV (Standard Minutes Value) = Basic Time + Allowances (generally 15% -20%)

The impact of lean adoption was determined by comparing lean initiated and non- lean initiated apparel units using interview cum questionnaire schedule. Experts from the industries and academicians having long experience were also consulted to check the suitability of the research instrument. The comments and feedback were analyzed and a few minor modifications were made especially in the questionnaire format. Thus the questionnaire was then ready for data collection. Out of total sample of 10 lean initiated and non-lean initiated units each, one unit each was selected for pretesting.

Data in terms of number of helpers, tailors, checkers, supervisors, machines used, working hours, loading production, number of garment inspected and defective garments was collected for all production

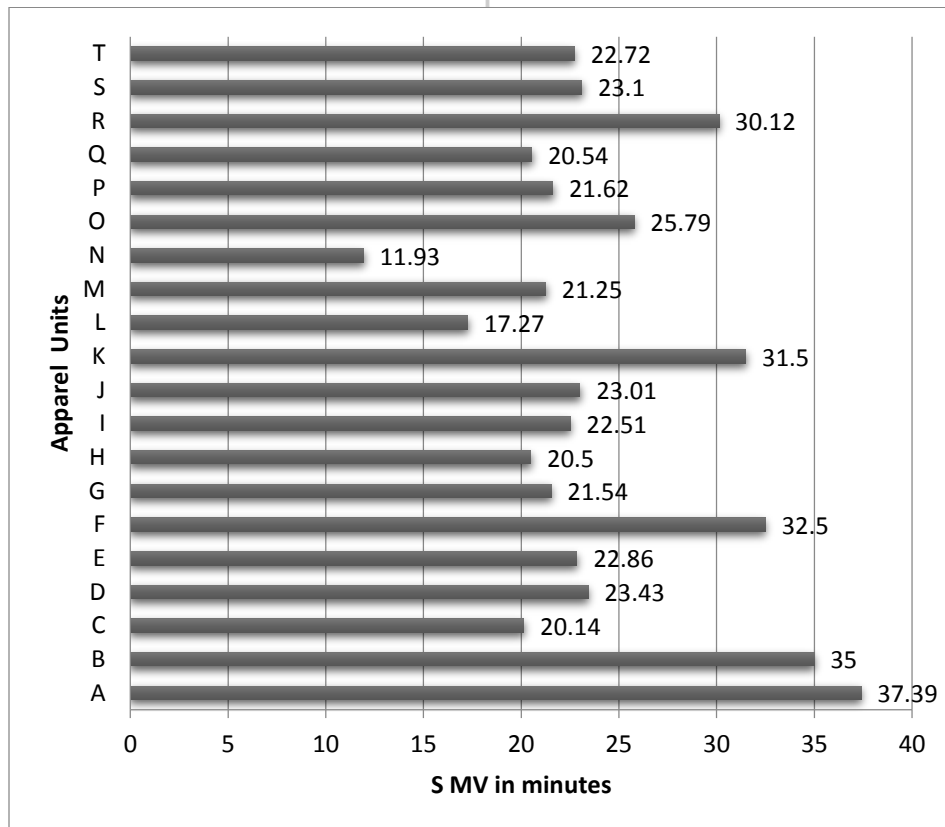
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days of the chosen design. Different defects found under the seven categories such as *fabric* including fabric flaw and shade variation; *stitching and construction* including open broken seam, pinching, skip or slip stitch, puckering or roping, uneven width or margin, uneven top stitch or raw stitch; *appearance* including poor neck or bottom shape, shine mark, uncut thread, uneven gather or smoking, balancing or joint out, label including wrong label, wrong placement, tilted label, insecure label, label missing; *damage* including needle cut or hole, sewing damage; *stains* including oil stain, handling stain, marking stain, gum marks; and ‘measurement out’ were collected.

## Results and Discussion

The results dealing with the comparative assessment of the improvement in the apparel unit in terms of manufacturing Key Performance Indicator are discussed below.

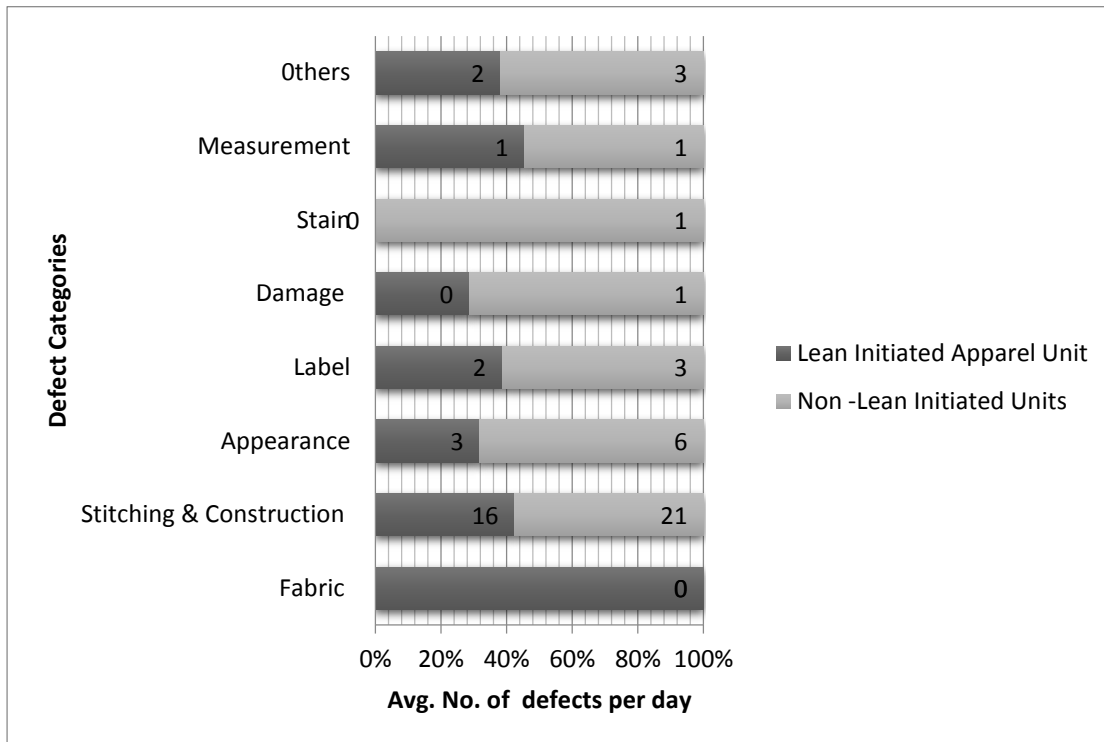
Time study was performed for the chosen garment. All operations performed in sewing of the selected style were written in sequence before starting the time study. Five readings were taken for each operation using stop watch and average observed time was noted which was further multiplied to rating factor to obtain ‘normal time’. Personal fatigue and delay allowance was added to get standard minute value of the garment. SMV was used in the calculation of efficiency. Average SMV of the common garment style in 20 apparel manufacturing unit, was found to be 25.54 minutes. Figure 3 shows the SMV of the ladies top or shirt obtained by all 20 units.



**Figure 3. Standard minute value of the common garment**

Figure 4 shows the comparative distribution of main defect categories. Stitching and construction defects were the highest in the non-lean initiated units as 21 defects per day in comparison to 16 in lean initiated units. It was followed by

appearance category defect with an average of three and six defects per day in lean initiated units and non-lean initiated units respectively. Stain category defect was found the lowest.

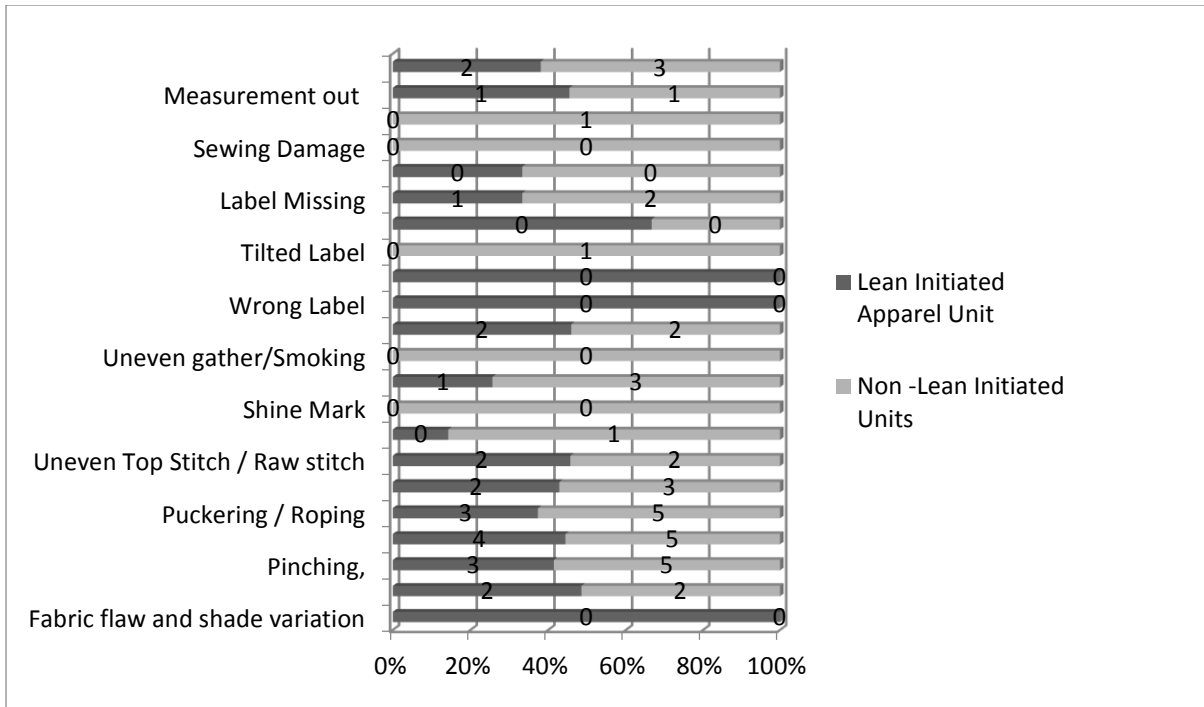


**Figure 4. Distribution on the basis of defect categories**

Further classification of the major defect categories is shown in Figure 5. It was revealed that slips or skips stitch defects were the highest with four and five per day in lean and non-lean initiated units respectively followed by pinching and

puckering or roping defects. In none of the units, defect categories such as sewing damage; needle or hole; insecure, wrong placement, and wrong label; uneven gathers; shine mark; and fabric flaw and shade variation were found.





**Figure 5. Distribution on the basis of types of defects**

The data collected was statistically tested for its normal distribution using One Sample Kolmogorov Smirnov test .The difference in data was found significant for operator productivity and total labor productivity revealing that the data was skewed and distribution was not normal and hence, non-parametric test that is Mann-Whitney U Test was used for further analysis as in case of dissimilar distributions, mean ranks are compared. The difference in data was found non-significant for efficiency, work in progress, defect hundred unit and percentage defective demonstrating that the data was normal and hence t-test was used for further statistical analysis.

*H<sub>a1</sub>: There is a significant difference in performance in terms of manufacturing key performance indicators namely productivity,*

*efficiency, quality, work in progress among lean initiated and non-lean initiated apparel units.*

The above stated hypothesis was framed with the aim of exploring the differences between the mean value of key performance indicators in lean and non-lean initiated apparel units. The result revealed that the lean initiated apparel export firms have higher operator productivity, total labor productivity and efficiency, than the non-lean initiated units. The mean score of defect hundred units (DHU) and percentage defective in lean initiated units were found lower than in non-lean initiated units except for work in progress. It implied that the lean initiated apparel manufacturing units in NCR shows better performance in terms of productivity, quality and efficiency than the non-lean initiated apparel firms.

**Table 1. Mean, Standard Deviation, and Mann-Whitney Analysis of Key Performance Indicators in Lean and Non-Lean Initiated Apparel Manufacturing Unit**

Variable	Category	M	SD	Mean Rank	Sum of Ranks	Mann-Whitney U Test	
						U	p-value
<b>Operator Productivity</b>	Lean	11.20	2.71	13.80	138.00	17.00	.011*
	Non-Lean	9.04	5.70	7.20	72.00		
<b>Total Labor Productivity</b>	Lean	9.17	2.47	13.60	136.00	19.00	.019*
	Non-Lean	7.30	4.48	7.40	74.00		

Note. N=20(Lean=10 & Non-Lean=10); ps = Spearman correlation coefficient; U= Mann-Whitney value. p-value<0.001=\*\*\*. p-value <0.01=\*\*. p-value <0.05=\*.p-value>0.05=ns.

The difference in the mean rank values of productivity in lean and non-lean apparel units revealed that mean of operator productivity and total labor productivity in lean initiated units was 11.29 and 9.17 respectively and was higher than non-lean initiated units as illustrated in the Table 1. To further test the hypothesis, Mann-Whitney U test was used and difference in the mean of operator productivity (U=17.00\*, p=0.11\*,  $\alpha=0.05$ ) and total labor productivity (U=19.00, p=.019\*,  $\alpha=0.05$ ) was found statistically significant as p<0.05. Hence the null hypothesis was rejected and alternate hypothesis was accepted stating that the operator and total labor productivity was significantly higher for the lean initiated apparel units in comparison to non-lean initiated apparel units. Result was supported

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by Blecha et al., 1993; Chakraborty and Paul, 2011; Dalgobind and Anjani, 2009; Farhana and Amir, 2009; Gamage et al., 2012a; Gomes, 2012; Hodge et al., 2011; Johnson, n.d.; Jozaffe, 2006; Karim and Rahman, 2012; and Stotz, 2010 stating that with the implementation of lean, productivity of the organization increases. Hallam, 2003 also concluded in his research that a firm with a lean production system had the potential to outperform a firm with a mass or craft production system, as it can deliver greater customer value with equal or fewer resources showing some forms of improvement in productivity, quality, and lead-time. Laohavichien and Wanarat (2013) also concluded in their research that lean practices had a positive influence on the operational performance.

**Table 2. Mean, Standard Deviation, and t- test Analysis of Key Performance Indicators in Lean and Non-Lean initiated Apparel Units N=20 (Lean=10 ,Non-Lean=10)**

Variables	Category	M	SD	t-test		
				t	df	p-value
Efficiency	Lean	62.12	13.08	4.29	18	.000**
	Non-Lean	38.40	11.60			
Work in Progress	Lean	513.72	241.03	1.84	18	.083ns
	Non-Lean	734.34	294.00			
Defect Hundred Unit	Lean	8.19	4.75	2.26	18	.036*
	Non-Lean	12.60	3.94			
Percentage Defective	Lean	7.08	3.84	2.71	18	.014*
	Non-Lean	11.53	3.48			

Note. *r*= Pearson's correlation coefficient; *t*= observed or calculated t –test value; *df*=Degree of freedom. Sig. (2-tailed) =two-tailed p value associated with the test. *p*-value<0.001=\*\*\*. *p*-value<0.01=\*\*. *p*-value<0.05=\*.*p*-value>0.05=ns.

The mean difference between lean initiated and non-lean initiated apparel units is evident in the Table 1 and Table 2. It was concluded that the lean initiated units had higher efficiency, low work in progress, defect hundred unit and percentage defective in comparison to non-lean units. A *t*-test revealed a statistically reliable difference between the mean number of key performance indicators of lean and non-lean initiated units as  $p < .05$ .

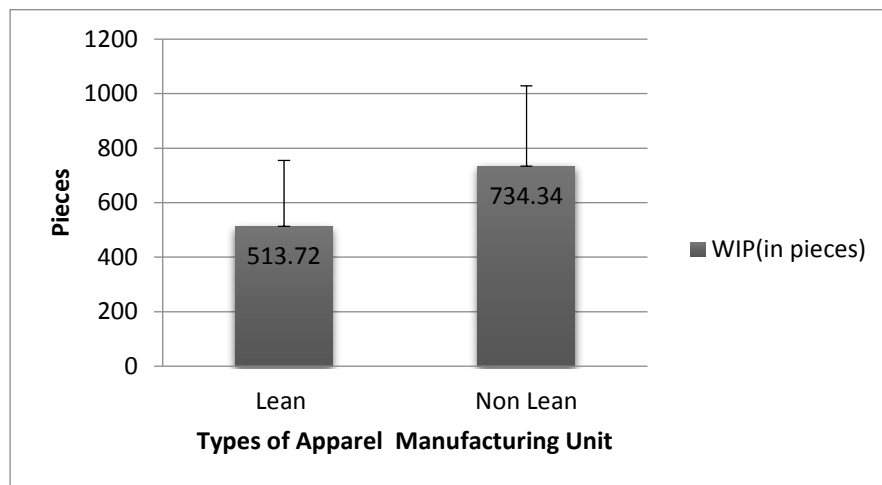
- Lean initiated units and the non-lean initiated units demonstrated a highly significant difference in the efficiency,  $t(18) = 4.29, p = 0.000^{**}, \alpha = .01$ ; as expected lean initiated unit has higher efficiency than non-Lean initiated apparel manufacturing unit. Increase in efficiency with lean implementation was also found in the researches by Gamage et al., 2012a; Gamage et al., 2012b; Gomes, 2012; Ratnayake, 2009; and Ratnayake et al., 2009.
- Lean initiated apparel manufacturing units and the non-lean initiated units

demonstrated a nonsignificant difference in the work in progress,  $t(18) = 1.84, p = 0.083, \alpha = .05$ . Even though average work in progress was lower in lean initiated units in comparison to non-lean initiated units as shown in Figure 4.90. The results were in contrast to the results obtained by Ahsan et al., 2011; Kumar and Sampath, 2012b; Paneru, 2011; and Ratnayake et al., 2009 revealing that WIP decreases up to 30% with the initiation of lean or implementation of Kaizen. No significant difference might be due to the fact that in order to reduce the inventory in a unit, all the basis tools along with few advanced tools like kanban or pull must be properly implemented. But most of the units had started their lean journey maximum 3 years ago and are at present mainly concentrating on basic tools. In some units, even though Kanban is implemented but it is between one or two departments instead of whole unit.

- Lean initiated units and the non-lean initiated units demonstrated a significant difference in the DHU,  $t(18) = -2.26, p = 0.036^*$  at 5% significance level as expected lean initiated unit has low DHU than non-lean initiated apparel manufacturing unit. The result was in concurrence with researches by the Ahsan et al., 2011; Kumar and Naidu, 2012b ; and Paneru, 2011; Ratnayake, 2009 which stated that DHU decreased up to 62% with the implementation of lean or Kaizen.
- Lean initiated units and the non-lean initiated units, demonstrated a significant difference in performance in

terms of percentage defective,  $t(18) = 2.71, p = 0.014^*, \alpha = .05$  as  $p < .05$ ; as expected lean initiated unit has low percentage defective than non-lean initiated apparel manufacturing unit. In the researches by Dalgobind and Anjani, 2009; Hodge et al., 2011; and Johnson, n.d. also, quality improvements were found after lean initiation.

Null hypothesis was rejected and alternate hypothesis was accepted implying that there is a significant difference in the efficiency, defect hundred unit and percentage defective among two types of units except for work in progress.



**Figure 6. Column Diagram Showing Error Bars with Standard Deviation of Work in Progress in Lean and Non-lean Initiated Apparel Units**

*H<sub>a2</sub>: Year of lean initiation makes a significant difference in the performance of the apparel unit in the terms of productivity, efficiency, quality, and work in progress.*

The hypothesis was stated with the aim of finding the impact of year of lean initiation on the performance of the apparel unit in terms of manufacturing and environmental key performance indicators. The data in the Table 3 below clearly demonstrates a mean difference in various key performance indicators in the apparel export units having implemented lean for more than 2 years and ones that had initiated lean in less than 2 years.

The t-test revealed a statistically significant difference between the mean for few performance indicators, implying apparel export firms having implemented lean for more than 2 years has higher efficiency, lower defect per hundred unit and percentage defective in comparison to the units that had implemented lean in less than 2 years as  $p < .01$ . But no significant difference in the mean scores of operator productivity, total labor productivity and work in progress was found in two groups depicting that the years of lean initiation does not make any difference in these variables.

**Table 3. Mean, Standard Deviation, and t-test Analysis of Year of Lean Initiation and Key Performance Indicators**

Variables	Year of Lean Initiation	M	SD	T	df	Sig(2-tailed)
Operator Productivity	≤2 years	11.04	<b>0.92</b>	-.18	8	.869ns
	>2 years	11.36	3.95			
Total Labor Productivity	≤2 years	8.84	0.86	-4.40	8	.706ns
	>2 years	9.50	3.56			
Efficiency	≤2 years	51.37	1.41	-4.91	8	.007**
	>2 years	72.86	9.69			
Work in Progress	≤2 years	584.44	251.95	.92	8	.385ns
	>2 years	443.01	233.95			
Defect Hundred Unit	≤2 years	11.84	3.30	3.93	8	.004**
	>2 years	4.53	2.53			
Percentage Defective	≤2 years	10.04	2.46	3.93	8	.004**
	>2 years	4.13	2.30			

Note. N=10 lean initiated units. t= observed or calculated t value; df=Degree of freedom. Sig. (2-tailed) =two-tailed p value associated with the test. p-value<0.001=\*\*\*. p-value<0.01=\*\*. p-value<0.05=.p-value>0.05=ns.

- A t test reveals that there is no statistically reliable difference between the mean number of operator productivity as apparel unit having implemented lean in *more than 2 years* has 11.36 and the apparel units having implemented lean within ‘*in less than 2 years*’ has 11.04 ,  $t(4) = -0.175$ ,  $p = 0.869$ ; as the p value is  $>0.05$ .
- The difference between the mean number of total labor productivity as 9.50 and 8.84 in apparel unit having implemented lean in *more than 2 years* and in *less than 2 years* respectively. No significant difference between both group of units was established as  $t(4) = 4.469$ ,  $p = 0.706$ ,  $\alpha = .05$ .
- Analysis of t test reveals that there is a statistically reliable difference between the mean number of efficiency as 72.86 and 51.37 for apparel unit having implemented lean in *more than 2 years* and having implemented lean in *less than 2 years* respectively as  $t(4) = 4.91$ ,  $p = 0.007^{**}$ ,  $\alpha = .01$ .
- The difference between the mean number of work in progress(WIP) in apparel unit having implemented lean in *more than* and *in less than 2 years* was

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- also found no statistically significant ,  $t(8) = .920$ ,  $p = 0.385$ ,  $\alpha = .05$ .
  - Statistically reliable mean difference of defect per hundred unit (DHU)( $t(8) = 3.930$ ,  $p = 0.004^{**}$ ,  $\alpha = .01$ ) was found in apparel unit having implemented lean in *more than* and *less than 2 years*. A t- test analysis clearly revealed that more the years into lean implementation, quality of the product improves with less defects per hundred unit
  - A t test reveals that there is a high statistically reliable difference between the mean number of percentage defective as apparel unit having implemented lean in *more than 2 years* obtained 4.13 and the apparel units having implemented lean in *less than 2 years* 10.04,  $t(8) = 3.929$ ,  $p = 0.004^{**}$ ,  $\alpha = .01$ .

It is thus concluded that even though the years of lean initiation had highly significant effect on the efficiency, defect per hundred unit and percentage defective, but, no significant effect was found on the rest of the performance factors that is productivity and WIP. Though Agus and Iteng (2013)

provided an evidence that the length of lean adoption is positively linked to the business performance and long term adopters of lean production benefit more in the long run. But in context to this research, the reason for finding non-significant difference in some performance indicators may be because that as it is believed that lean is a long term philosophy and it takes 3 to 5 years to get real benefits and the units which were included in the research have initiated lean since two to three years. The results were also supported by the viewpoint given by lean expert in phase I that even though all the phases of lean implementation follow a general sequence, the degrees to which they overlap and interconnect depends on each apparel manufacturing unit's working environment and the skill and experience of its chosen lean guide.

## Conclusion

Importance of using manufacturing Key performance indicators (KPIs) is clear in the words of Tom Tuttle stating that resources flow toward what is measured. The indicators also helped in reporting the lean progress towards achieving the desired results. After the comparative performance assessment of lean initiated and non-lean initiated apparel manufacturing units in terms of KPIs, it was concluded that lean initiated apparel manufacturing units in NCR showed better performance in terms of operator productivity, total labor productivity, defect hundred unit, percentage defective and efficiency than non-lean initiated apparel firms except for work in progress. The years of lean initiation was also found to have highly significant effect on the efficiency, defect per hundred unit, and percentage defective except for productivity, and work in progress. Hence with the increase in the time of lean initiation, the performance also gets better.

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