CHAPTER 4
DESCRIPTIVE STATISTICS

4.1 INTRODUCTION

This chapter gives the results of the descriptive statistics of the variable of lean manufacturing practices and sustainability performance of the MSMEs, by analysing the data from the questionnaire survey. The questionnaire used for the data collection has 19 variables related to LMPs, 12 variables related to sustainability performances and 16 items related to the areas of linkage between lean and sustainability. The responses were collected on a '5 point Likert scale'. Descriptive statistics was carried out by calculating the mean and standard deviations of responses of variables.

4.2 DESCRIPTIVE STATISTICS OF LMPS

Over the 19 variables related to LMPs, the respondents were requested to respond whether they are agreeing with the respective statements representing variables with respect to their firm. The statements representing the LMPs are given in the Table 3.1. The mean and standard deviations are calculated for each variable concerning the responses obtained in the given scale. Table 4.1 gives the variable code, statement of variables, calculated mean and standard deviation and the rank of the variables based on the mean values. Table 4.1 also indicates the level of acceptance of these practices in the MSME firms.

The responses were collected on a five-point Likert scale,ranging from 1 to 5. The middle point of the scale 3.0 indicates the respondents neither agree nor disagree with the use of the particular lean practice in their firm. The higher values indicate a higher-level adoption of these practices. The results show that the mean value of the lean practices ranges from 2.079 to 4.262 and the standard deviation from 0.7952 to 1.3498. It can be observed that the mean values of the responses of all individual practices are higher than 3.0, except for two practices indicates that lean practices and principles are followed by the firms to a good extent.

Table 4.1 Descriptive Analysis of Lean Practices

Variable Code	Variable	Mean	Standard Deviation	Rank
LMP01	Our plant emphasise putting all tools and fixtures in their proper place	3.952	0.8869	5
LMP02	We use standardized and documented processes which are well instructed to our employees	3.897	1.0125	6
LMP03	We focus to reduce process set up time -- the time required to prepare or refit equipment, workstations etc.	3.544	1.1613	12
LMP04	Workers carry out routine maintenance on all equipment (e.g., Cleaning, lubrication or small repairs) following standard procedures	3.845	1.1689	7
LMP05	Many equipment problems have been solved through small group sessions	3.202	1.2380	17
LMP06	Our plant following either preventive/predictive maintenance	3.706	1.2178	11
LMP07	We use Kanban pull system (or containers of signals) for production control	2.079	1.0976	19
LMP08	We can depend on time delivery of our suppliers	3.984	0.8925	3
LMP09	We have built close, long-term relationships with our suppliers	4.262	0.7952	1
LMP10	We have high levels of information transparency or information sharing with our suppliers	3.841	0.9607	8
LMP11	We form teams capable to do their daily work without formal leadership.	3.294	1.2405	16
LMP12	During problem-solving sessions, we make an effort to get all team members' opinions and ideas before making a decision	3.353	1.2134	14
LMP13	We systematically and regularly measure customer satisfaction	3.984	1.0636	4
LMP14	We usually complete our daily schedule as planned	3.782	1.0543	10
LMP15	We have a small amount of work-in-process inventory	3.437	1.0932	13
LMP16	The layout of the shop floor facilitates low inventories and fast throughput	3.341	1.0871	15
LMP17	We emphasise the continuous improvement of product quality in all work processes	2.897	1.3498	18
LMP18	We have an effective process for resolving customers' complaints	4.135	0.9685	2
LMP19	Customer needs and expectations are effectively disseminated and understood throughout the workforce	3.813	1.0790	9

From the Table 4.1, it can be stated that the two items were the most used lean practices which having mean values more than 4.0. The items included in this list are maintaining ‘long-term supplier relationship’ (LMP09) and ‘customer care’ by an efficient process for resolving customer complaint (LMP18). Depending on time delivery of suppliers (LMP08), systematically and regularly measure of customer satisfaction (LMP13) and process management by emphasising to put all tools and fixtures in the proper place (LMP01) are the practices having the mean values near to 4.0. The two practices, which have mean values less than 3.0, are Kanban pull system (LMP07) and continuous improvement (LMP17).

The findings of this analysis are comparable with similar studies. The results are related to studies by Pannizzolo et al. (2012) in Indian SMEs and by Filho et al. (2016) in Brazilian SMEs except for some findings as the key suppliers delivering to the plant on a just-in-time basis are very rarely used by the SMEs. The results show that MSMEs in the sample frame are following and practising the most of the LMPs.

4.3 DESCRIPTIVE STATISTICS OF SUSTAINABILITY PERFORMANCE

The mean and standard deviation of the responses to the sustainability performance of the firms obtained on a five-point Likert scale on 'much worse' (1) to 'much better' (5) are calculated and tabulated in Table 4.2. The respondents were requested to record their performances measured in comparison with their primary competitors in the last three years. The mean value of the sustainability performances ranges from 3.413 to 4.234 and standard deviation 0.7229 to 1.0593.

From the Table 4.2, labour relationship (SP09), safety and health (SP08), and decreases in the rate of customer complaints (SP11) are the more important sustainability performances from lean practices as the mean values are greater than 4.0. This result is the clear indication of the social relevance of lean practices in sustainability benefits. Technology improvement (SP12), growth in market value (SP02) and reduction in emission/unit of production (SP05) are the sustainability performances in the next three positions.

Table 4.2 Descriptive Analysis of Sustainability Performances of Lean

Variable Code	Sustainability Benefits of lean	Min	Max	Mean	Std. Deviation	Rank
SP01	Low Operational cost	1.0	5.0	3.413	1.0002	12
SP02	Growth in Market Value	1.0	5.0	3.738	0.9292	5
SP03	Growth in Profit	1.0	5.0	3.504	0.9510	10
SP04	Reduction Business wastage	1.0	5.0	3.627	0.8992	8
SP05	Reduction in Emission /unit of Production	1.0	5.0	3.690	0.8465	6
SP06	Reduction in Material Usage/ Output	1.0	5.0	3.460	0.9116	11
SP07	Reduction in Energy/ Fuel usage	1.0	5.0	3.619	0.9047	9
SP08	Safety and health	1.0	5.0	4.004	0.7858	2
SP09	Labour relationship	1.0	5.0	4.234	0.7229	1
SP10	Training and Education	1.0	5.0	3.655	1.0390	7
SP11	Decrease in rate of consumer complaints	1.0	5.0	4.000	0.9015	3
SP12	Technology Improvement	1.0	5.0	3.885	1.0593	4

Reduction in business wastage (SP04), reduction in emission per unit of production (SP05), and the reduction in material usage per output (SP06) are environmental benefits. Reduction in operational cost (SP01), Growth in market value (SP02) and growth in profit (SP03) are the indication of the economic benefit of lean practices. The least mean value of all the responses is 3.413. This result indicates the general agreement among all the respondents on all the sustainability benefits contributing to the lean practices.

4.4 DESCRIPTIVE STATISTICS OF AREAS OF LINKAGE BETWEEN LEAN AND SUSTAINABILITY

The responses to the sixteen areas of linkages identified between lean and sustainability are tabulated in Table 4.3. The respondents were requested to rate their responses on the five-point Likert scale, whether they strongly disagree (1) to strongly agree (5) about each area of linkage as relevant to their firm.

4.4.1 RANKING THE AREA OF LINKAGE BETWEEN LEAN AND SUSTAINABILITY

The ranking of the attributes by the mean value was used to understand the position of the attributes by the priority given by respondents. The standard deviation

is used as a bar if it two attributes came with the same mean, the attribute with lower standard deviation was assigned the highest rank. As per the ranking by the mean value, waste reduction, better quality and health and safety are the most important areas. Continuous improvement, worker empowerment, performance improvement and value maximisation are the next important areas of linkage. Community strategy, governance, and optimum design are the less important areas of linkages

Table 4.3 Ranking of Area of Linkage Between Lean and Sustainability

Areas of Linkage between lean and sustainability	Sample size	Minimum	Maximum	Mean	Std. Deviation	Rank
Waste reduction	252	1.0	5.0	4.167	0.8769	1
Better Quality	252	1.0	5.0	4.063	0.8677	2
Health and Safety Management	252	1.0	5.0	4.048	0.8118	3
Continuous Improvement	252	1.0	5.0	3.921	0.9112	4
Worker Empowerment	252	1.0	5.0	3.913	0.8928	5
Performance Improvement	252	1.0	5.0	3.865	0.8958	6
Value Maximization	252	1.0	5.0	3.833	1.0275	7
Environment Management	252	1.0	5.0	3.706	1.0065	8
Resource Management	252	1.0	5.0	3.579	0.9392	9
Cost Reduction	252	1.0	5.0	3.563	1.0562	10
Supply chain Management	252	1.0	5.0	3.520	1.0195	11
Transparency	252	1.0	5.0	3.496	1.0119	12
Energy Minimization	252	1.0	5.0	3.492	1.1023	13
Community Strategy	252	1.0	5.0	3.262	0.9793	14
Governance	252	1.0	5.0	3.218	1.0730	15
Optimum Design	252	1.0	5.0	2.095	1.1576	16

4.4.2 ONE- SAMPLE T-TEST

One sample t-test was used to test the variation in the sample mean to the hypothesised mean of the attributes representing the area of linkage and the lean sustainability benefits. A hypothesised mean (Uo) of the attributes is fixed at 3.0 as the study used a five-point Likert scale to rate the attributes. This hypothesis implies that the attribute is important when the mean value is above 3.0. The null hypotheses are defined for each attribute, as all attributes are unimportant. This indicates the sample

mean of each attribute equal to hypothesised mean value. The alternative hypotheses are defined, as each attribute are important indicates sample means are higher than the hypothesised mean values. A two-tailed significance level of each attribute can be measured using the one sample t-test. Half of this two-tailed p-value gives the p-value for the one tail test, which is the criterion for the significance of the attributes. These tests were conducted at a confidence level of 95 percentages.

One-sample test with a test value equal to 3.0 is conducted as shown in Table 4.4 to identify the significance of each attribute. This two-tailed test shows that all the areas are significant ($p < 0.05$) except the area of 'optimum design' ($p = 0.480$) in the contest of linkage between lean and sustainability. Hence, from further analysis, the attribute 'optimum design' is removed.

Table 4.4 One-sample t-Test for Testing the Significance of the Areas of Linkage Between Lean and Sustainability

Areas of Linkage between Lean and Sustainability	**Test Value = 3.0**					
	t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
Waste reduction	21.121	251	0.000	1.1667	1.058	1.275
Environment Management	11.141	251	0.000	0.7063	0.581	0.831
Supply chain Management	8.094	251	0.000	0.5198	0.393	0.646
Worker Empowerment	16.228	251	0.000	0.9127	0.802	1.023
Better Quality	19.456	251	0.000	1.0635	0.956	1.171
Health and Safety Management	20.485	251	0.000	1.0476	0.947	1.148
Value Maximization	12.875	251	0.000	0.8333	0.706	0.961
Energy Minimization	7.086	251	0.000	0.4921	0.355	0.629
Resource Management	9.792	251	0.000	0.5794	0.463	0.696
Optimum Design	0.707	251	**0.480**	0.0516	0.092	0.195
Cost Reduction	8.470	251	0.000	0.5635	0.432	0.695
Performance Improvement	15.330	251	0.000	0.8651	0.754	0.976
Transparency	7.782	251	0.000	0.4960	0.370	0.622
Continuous Improvement	16.038	251	0.000	0.9206	0.808	1.034
Community Strategy	4.246	251	0.000	0.2619	0.140	0.383
Governance	3.229	251	0.001	0.2183	0.085	0.351

4.5 OPERATIONAL MANAGEMENT SYSTEM - GROUPING VARIABLES

All the 15 areas of linkage that are identified and found to be significant, may not be relevant to a particular type of industry (Piercy and Rich, 2015). This postulate is true because, the sustainability is influenced by the 'operational management system' variables or grouping variables of the firms (Jayaraman et al., 2012)

This means that, the operational system characteristics of the firm will affect the list of relevant areas of linkages between lean and sustainability of the firm. So when the significance of all the identified areas of linkage between lean and sustainability are considered, there may be statistical differences among the groups of the firms classified based on the operational system characteristics.

The knowledge of whether the different operating system characteristics are affecting or not, the lean sustainability integration will help the policy makers in framing the policies of lean and sustainability for the different groups of MSMEs. For the study reported here, four operational system variables were selected for the analysis. These variables are, (1) level of investment (Micro, Small and Medium), (2) manufacturing sector (Metal, Automotive, Chemical, plastic, etc.), (3) type of manufacturing process (Job shop, flow shop and batch production) and (4) type of production system (make/ assemble to stock or order). The respondents were grouped according to this four grouping variables depending on the operational system. The statistical differences among the various groups of respondents were investigated in the areas of linkages between lean and sustainability. The Kruskal–Wallis Chi-square test helps to examine whether the difference, according to the grouping variables are significant or not. The 'Kruskal–Wallis test' is a non-parametric test to investigate the difference between groups without following normal distribution.

The null hypothesis states that there is no significant difference and alternative hypothesis states that there is a statistical difference, between the groups of respondents' classified based on grouping variables, related to areas of linkages. If significant differences exist, post-hoc tests will be required to determine the nature of these differences.

4.5.1 LEVEL OF INVESTMENT

This classification is based on the level of investment in plant and machinery according to MSMED act 2006. In this classification, firms are categorised into three groups, namely, micro, small and medium firms. The frequency of each category of the firms responded to the survey is shown in Figure 4.1 with a percentage of 13.5, 67.9 and 18.6 % respectively

Figure 4.1 Categorisation Based on the Level of Investment

The Kruskal-Wallis test is conducted to present the statistical difference between the firms with different levels of investment.

Table 4.5 Kruskal-Wallis Test for Statistical Difference Between Firms at Different Levels of Investment

Area of linkage between lean and sustainability	x^2	d f	Asymp.sig
Waste reduction	6.334	2	0.042
Environment Management	17.728	2	0.000
Supply chain Management	33.95	2	0.000
Worker Empowerment	13.276	2	0.010
Better Quality	16.638	2	0.000
Health and Safety Management	16.698	2	0.000
Value Maximization	23.527	2	0.000
Energy Minimization	33.502	2	0.000
Resource Management	27.656	2	0.000
Cost Reduction	24.274	2	0.000
Performance Improvement	17.610	2	0.000
Transparency	18.392	2	0.000
Continuous Improvement	23.366	2	0.000
Community Strategy	15.729	2	0.000
Governance	30.617	2	0.000

Note: Kruskal-Wallis Test based on grouping variable-Level of investment

As evident from Table 4.5, all the variables of areas of linkages giving p-values less than 0.05 while applying Kruskal -Wallis test based on the grouping variable 'level of investment'. As the p-values are < 0.05, null hypothesis are rejected. This result indicates a statistically significant difference among the firms classified according to grouping variable 'the level of investment in all areas of linkage between lean and sustainability

4.5.2 TYPE OF MANUFACTURING PROCESS

The grouping based on the manufacturing process split the responding firm into three categories such as job shop, batch production, and flow shop. The frequency of each category are shown in Figure 4.2. The percentage of the firms responded to the survey under each category are 15.2, 52.9 and 32.9 % respectively.

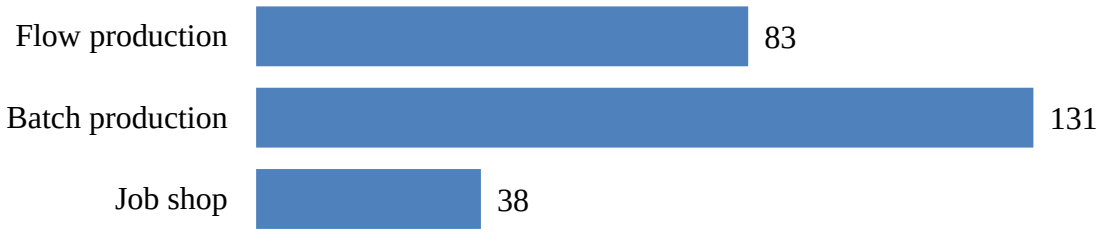

Figure 4.2 Categorisation Based on Types of Manufacturing Process

In Table 4.6, Kruskal-Wallis test was applied to categorise the firms based on this grouping variable. This test confirms that the seven areas of linkages namely waste reduction, environmental management, supply chain management, energy minimisation, resource management, community management and governance having a p-value < 0.05 leads to the rejection of null hypothesis, which indicates a statistically significant difference according to the grouping variable. All other areas, namely worker empowerment, quality, health and safety management, value maximisation, cost reduction, performance improvement, transparency, and continuous improvement, have p-values > 0.05. This result indicates no statistical divergence of the firms classified according to the nature of manufacturing processes in these eight areas of linkages between lean and sustainability.

Table 4. 6 Kruskal-Wallis Test for Statistical Difference Between Job shop, Batch and Flow Production Manufacturing Processes

Area of linkage between lean and sustainability	x^2	df	Asymp. Sig
Waste reduction	11.038	2	0.004
Environment Management	17.167	2	0.000
Supply Chain Management	9.202	2	0.010
Worker Empowerment	4.776	2	0.092
Better Quality	3.918	2	0.141
Health and Safety Management	5.341	2	0.069
Value Maximization	2.279	2	0.320
Energy Minimization	8.501	2	0.014
Resource Management	6.125	2	0.047
Cost Reduction	4.645	2	0.098
Performance Improvement	4.004	2	0.135
Transparency	5.788	2	0.055
Continuous Improvement	2.461	2	0.292
Community Strategy	7.759	2	0.021
Governance	10.224	2	0.006

Note: Kruskal-Wallis Test based on grouping variable: Type of Manufacturing Processes

4.5.3 TYPE OF PRODUCTION SYSTEM

Based on the type of production system, firms are categorised into ‘make to stock’, ‘make to order’, ‘assemble to stock’, and ‘assemble to order’. The frequency of each category is shown in Figure 4.3. The percentage of firms responded to survey under each category are 32.1, 58.7, 3.2 and 6 % respectively.

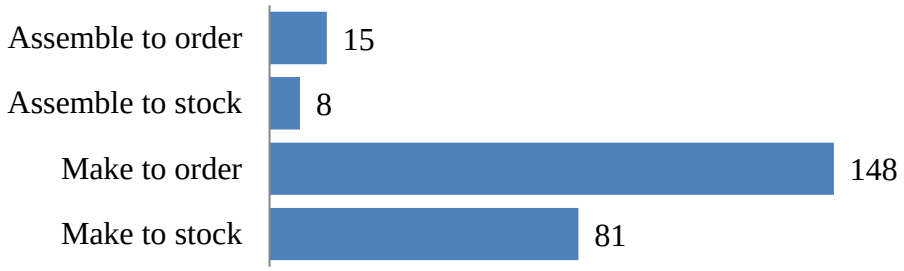

Figure 4.3 Categorisation Based on Type of Production System

Results of the Kruskal Wallis- chi-square test carried out are shown in Table 4.7 to test the statistical divergence of the respondents based on the production systems.

The degree of freedom observed for the test is equal to three. The asymptotic significances of the attributes are found less than 0.05 for the attribute ‘environment management’ and ‘value maximisation'. For all other attributes, the value of asymptotic significance is above 0.05. The asymptotic significance (p-value) is greater than 0.05 indicates null hypothesis cannot be accepted. This implies that there is no statistical divergence among the different production systems in MSMEs except the attributes environmental management and value maximisation.

Table 4.7. Kruskal-Wallis Test for Statistical Difference Between Various Production Systems- Make or Assemble to Stock or Order

Area of linkage	x^2	*df*	*Asymp. Sig*
Waste reduction	2.091	3	0.554
Environment Management	12.721	3	0.005
Supply chain Management	6.113	3	0.106
Worker Empowerment	3.696	3	0.296
Better Quality	0.975	3	0.807
Health and Safety Management	4.48	3	0.214
Value Maximization	8.092	3	0.044
Energy Minimization	3.553	3	0.314
Resource Management	0.846	3	0.839
Cost Reduction	1.994	3	0.574
Performance Improvement	0.159	3	0.984
Transparency	0.942	3	0.815
Continuous Improvement	0.066	3	0.996
Community Strategy	2.352	3	0.503
Governance	3.465	3	0.325

Note: Kruskal-Wallis Test based on grouping variable: Type of production system

4.5.4 TYPE OF MANUFACTURING SECTOR

This grouping is based on the product of the firm. In this classification, manufacturing companies from 10 different sectors, namely automotive/machinery, metal/mechanical, electrical/electronics, food, paper, plastic/polymers, rubber, textiles/ garments, chemical, and wood. The Figure 4.4 gives the bar chart of the frequency of each sector in the study. The percentage of firms responded in each category are 8.7, 18.7, 6.0, 15.1, 3.2, 17.5, 7.9, 2.4, 17.1, 3.6 % respectively.

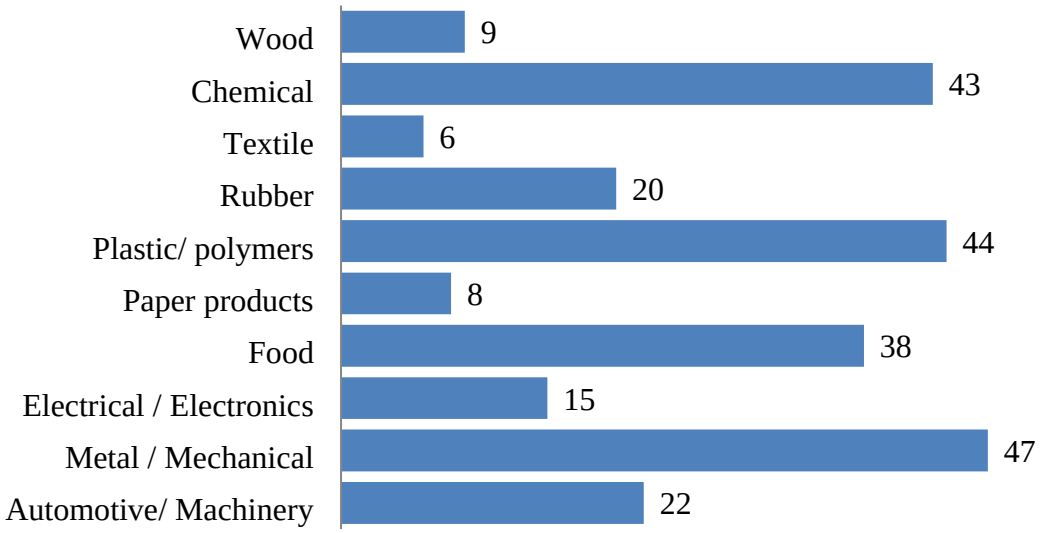

Figure 4.4 Categorisation Based on Manufacturing Sector

. In Table 4.8, the results of the Kruskal-Wallis test applied based on the grouping variable, 'manufacturing sector' is presented.

Table 4.8. Statistical Difference Between Various Manufacturing Sectors.

Area of linkage of lean and sustainability	x^2	df	Asymp. Sig
Waste reduction	8.824	9	0.454
Environment Management	8.01	9	0.533
Supply chain Management	10.346	9	0.322
Worker Empowerment	7.919	9	0.542
Better Quality	12.219	9	0.201
Health and Safety Management	8.469	9	0.488
Value Maximization	5.700	9	0.770
Energy Minimization	8.043	9	0.530
Resource Management	13.807	9	0.129
Cost Reduction	10.081	9	0.344
Performance Improvement	19.405	9	0.022
Transparency	7.473	9	0.588
Continuous Improvement	14.385	9	0.109
Community Strategy	16.156	9	0.064
Governance	12.83	9	0.170

Note: Kruskal-Wallis Test based on grouping vavariable: Type of Manufacturing sector

All the asymptotic significance (P Value) are greater than 0.05 indicates that null hypothesis cannot be accepted. This implies that there is no statistical divergence

among the respondents from different manufacturing sectors in the case of areas of linkages between lean and sustainability.

4.6 CONCLUSION

The descriptive statistics of lean practices shows that the mean value of lean manufacturing practices ranges from 2.079 (Kanban pull system) to 4.262 (Long-term supplier relationship). Long-term supplier relationship, customer-focused business and workplace organisation etc. are the mostly used lean practices. The outcome of the analysis hints that the LMPs are convincingly followed in Indian MSMEs.

The descriptive analysis of sustainability performance indicates that the 'labour relationship', 'health and safety' and 'decrease in the rate of customer complaints' are three important benefits of synchronising lean and sustainability. This result is the clear indication of the social relevance of lean practices in sustainability aspects. The respondents have agreed to all the benefits listed in the study, which is evident from the least mean value of all benefits being 3.143.

The study shows that waste reduction is the most important area of linkage between lean and sustainability. All forms of wastes are non-value added activities, which will affect the economic and environmental sustainability of the firms. Quality and safety are other important area of linkage between the lean and sustainability. All the listed areas of linkage except the optimum design are important, as the least mean value of the attributes obtained is 3.218. This result is a clear and reliable indication of synergies of lean and sustainability in manufacturing MSMEs.

The non-parametric Kruskal Wallis test was used to investigate the effect of four grouping variables in the areas of linkages between lean and sustainability. The Kruskal-Wallis test shows that a significant difference exists among the respondents classified according to the level of investment in plant and machinery in the area of linkage between lean and sustainability. These findings indicate the necessity of detailed study of linkages between lean and sustainability independently in different investment levels.

The Kruskal-Wallis test based on the grouping variable, ‘type of manufacturing process’, shows that no statistically significant difference exist among the respondents of the job, batch and flow production processes in more than 50 percent of the listed area of linkage between lean and sustainability. Similarly, test results imply that there is no statistical difference between the respondents from different production systems except the attribute ‘environmental management’ and ‘value maximisation’ in connection with these areas of linkages. In another test, respondents classified based on various manufacturing sectors have no difference in these areas of linkages between lean and sustainability.

The sample of industries selected for the survey includes ten diverse manufacturing sectors of MSMEs. As the respondents from diverse sectors are included in the sample, the conclusions drawn from this study can take a broad view to a great extent of MSMEs. The affinity of lean, and sustainability, and benefits discovered in this research can provide the support for managers to prevail over the confrontation to either approach at multiple levels. Apart from these, the practitioners can highlight the relevance of lean practices, which would be a requirement for the success of manufacturing MSMEs and their survival in a global environment.

Thus, this chapter statistically identified the various LMPs, sustainability performance measures and areas of linkages between lean and sustainability, which are relevant to MSMEs. The chapter also gives statistical differences among the groups of the MSMEs classified based on the various operational management system variables so that the objectives from one to three stated in section 1.3 are satisfied.