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Impact of lean philosophies on competitiveness in the context of Indian industries

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Abstract: Lean philosophies ,a set of tools and techniques for the betterment of the efficiency of a process is studied and discussed widely throughout the globe but when it comes to Indian industries there is still a need for more research to find out the correlation of lean philosophies with the benefits observed by the industries so that efficacy of various lean practices/bundles can be identified in context of a specific area of advantage obtained by a collective application of a variety of techniques. Therefore a questionnaire survey was conducted and the data obtained from various Indian industries was processed using statistical analysis software called SPSS.

Keywords: Lean manufacturing; lean processes; advantages; factors; statistical analysis; Indian industries; survey; questionnaire.

Introduction

Before the era of 2nd world war, it was believed that the methodology of mass production is the only way of increasing profit by increasing the number of products but as soon as the 2nd world war began and it created adverse effects on the human resource ,material resource and financial resources of different nations. Then It were Japanese who first understood that now to sustain growth ,mass production is not the solution and they devised various techniques which pressurized manufacturing system to be more efficient by eliminating every kind waste which could be blamed for non value addition of the product. Taiichi Ohno of Toyota Motor Corporation did remarkable improvements in their manufacturing plants which put emphasis on increasing the overall efficiency of the production and management system rather than focusing on productivity increase only. Various practices which were used in Toyota production system were termed as Lean manufacturing practices and the practice incorporating these practices were termed as Lean manufacturing as the main objective of all of these practices is to make the manufacturing system leaner and hence fitter.

Toyota production system set a benchmark for the efficient manufacturing and today itself Toyota is one of the most reputed brands of the world who are known for providing excellent quality and value to their customers. The basic principle of Toyota production system is to eliminate various wastes associated with the system as a whole and to produce with fewer resources, providing more value to the customer. After the grand success of Toyota production system, US researchers were anxious to explore the reason for the success of Japanese and the book “The Machine that Changed the World”, written by Woamck et al. (1990) further increased this anxiety and more and more researchers started to research on the Toyota production system. Toyota production system was termed as lean manufacturing system by these researchers and its tools and techniques were studied in different countries and their results were found to be positive across variety of industries. Right from the success of Toyota production system, effects of lean manufacturing are being studied in almost every region of world and most of authors have mentioned significant improvement in different industries due to the employment of lean manufacturing philosophies.

Shah & Ward (2002) identified 22 lean practices with the help of vast literature review and grouped them into four main lean bundles namely Just in time. Total quality management, Total preventive maintenance and Human resource management. A survey was carried out to find out how 22 lean practices, as a bundle or independently help the firms achieving their goal based on the six performance parameters and concluded that Total quality management and Human resource management are equally applicable on discrete as well as process industries where Total preventive maintenance is more applicable in process industries and Just in time is more likely to be adopted in discrete industries. Further the research work revealed that the implementation of lean practices is not affected by the plant size. Unionization was seen to have negative impact on the implementation of lean practices. In the study; most of the lean practices were found to have no relation with the age of the plant.

Bonavia & Marin (2006) studied the extent of implementation of various lean practices and tried to find out the relation between these lean practices with the size of the plant and effect on the operational performance. The research work is based on the survey responses obtained from 76 different plants from Spanish ceramic industry having specialization in single firing ceramics. It was concluded that the extent of implementation is related to the size of the plant and some lean practices are more practiced than the other and total productive maintenance (TPM), Standardization of operation and Quality control are practiced largely than Group technology, Kanban, Reduction of set-up time, Development of multifunction employees and Visual factory. It was also found that there is no significant effect on performance parameters if any of specific lean practice is adopted alone. Plant size and type of production process were used as control variables in their research. Authors used following performance variables to conduct research: -
Lead time; Stock; Quality; Productivity

Wan (2006) aimed at proposing the method to measure the leanness level of the manufacturing system along with the identification of the target level of leanness and put emphasis on the determination of leanness of the system with the development of lean metrics. It was stated that present scenario is to measure the performance against predefined lean indicators which focus on one specific area only and a measure of overall leanness still need to be established. Due to fast changing market trends, achieving leanness is not the only goal and the prime focus is on the quick response to uncertainty in demand. Agility and leanness both may be the contrary statements to each other so a manufacturing system should seek a fine balance between both of them. To analyze the leanness of the system using Data Envelopment Analysis, methodology was proposed. With the help of slack based measurement model, DEA is developed to measure the degree of leanness of each decision making unit. Research work utilized methodology in which value of leanness score could vary between 0 and 1 and to provide real time data of cost and time, a web based kanban was deployed.

Abdulmalek & Rajgopal (2007) selected a large steel plant for case study to find out the extent of lean manufacturing tools and techniques in steel industry which is a process sector industry. Current state map of the plant was prepared to find out the sources of waste along with the future state map after the application of lean tools. To cut down the expenses and due to uncertainty in results, simulation model was used to study the improvements and it was concluded that 5s, value stream mapping and visual systems are few lean tools which are universally applicable to the steel industries and lean tools are beneficial for the process industry also.

Pont et al. (2008) argued that to study the effects of lean practices as bundles is of more importance than to study them alone as similar lean practices ,when grouped together in bundles could give better results so authors have classified lean practices into 3 different bundles which are given below:-

Human Resource Management (HRM); Just in Time (JIT); Total Quality Management (TQM)
Authors tried to find out the intricate relations among these lean bundles and operational performance. They have chosen operational performance areas as given below:-

Quality; Dependability; Speed (of operations); Flexibility; Cost
To study the effects and interrelationship of lean bundles and performance parameters, 266 plants associated with three industries namely Machinery, Auto suppliers and Electronics from 9 countries were surveyed based on 13 different questionnaires. Structural equation model was used to study the data obtained from the survey of these firms and it was concluded that JIT and TQM are the lean bundles which have direct effect on the operational performance and this effect is positive whereas HRM has a mediating effect however it is also a positive effect on the operational performance.

Sahoo et al. (2008) focused on the implementation of lean strategies to a company situated in East India which deals with forging process using radial forging production lines to manufacture parts. The aim being the reduction of wastes, value stream mapping was applied to the manufacturing process and the maps were employed for the present as well as future states so that there is an improvement in the production process with the identification of wastes along with the knowledge of their sources.

Arashpour et al. (2009) proposed that total productive maintenance is a management technique which involves self directed maintenance with the involvement of many different strategies including the maintenance by machine operator himself. Research work aims at the reviewing of lean and TPM concepts by taking the case studies of popular firms including the results and obstacles associated with the implementation of Total Productive Maintenance. Case study of two firms which had employed TPM without the consideration of lean aspect of TPM is done. It was concluded that there are some common techniques between TPM and Lean and a firm should employ these techniques step by step to achieve best results and revealed that lean thinking should be developed first to achieve manufacturing excellence.

Singh & Sharma (2009) discussed that main focus of any firm remains on the production of quality products suited for the demand of customers along with the reduction of several types of wastes. VSM is a powerful tool which is helpful in the above said strategy of lean manufacturing. An Indian firm was taken for the case study and value stream maps were prepared for the same for current state as well as future state. It was concluded that VSM is an effective tool which helps industries to achieve the benefits associated with lean manufacturing as study indicated large reductions in lead time and work in progress along with moderate reductions in manpower requirement.

Wong et al. (2009) carried out a research on the implementation of lean manufacturing in the Malaysian electrical and electronics industry through a questionnaire survey covering 14 key areas of lean manufacturing. These 14 key areas are taken as following: - Scheduling ;Inventory; Material handling; Equipment; Work process; Quality; Employees; Layout; Suppliers; Customers; Safety and ergonomics; Product design; Management and culture; Tools and techniques.
Authors designed questionnaire based on 5 point likert scale and the whole questionnaire was divided into two parts which are discussed below:-

- Part 1 of the questionnaire was intended to survey the organization background, no of employees, products, benefits and obstacles in the implementation of lean.
- Part 2 of the questionnaire was intended to investigate the extent of implementation of lean manufacturing and its effects of 14 key areas which were short listed earlier.

Industrial data was gathered from a total of 44 surveys. Waste reduction and continuous improvement were identified as the main cause by the firms to apply lean. Reduced costs and improved productivity were marked as the results obtained from lean manufacturing. 5s and Kaizen were found to be most employed practices whereas group technology was the least employed lean practice. Further it was observed that more lean techniques are adopted together to reap the benefits of lean in a holistic approach. Human factor was found as main obstacle in the implementation of lean philosophy.
B. Singh et al. (2010) carried out a questionnaire survey to find out the scope of implementation of lean strategy in Indian industry. For this a questionnaire was prepared and sent to various Indian firms falling under three categories namely manufacturing industry, machine tool industry and automobile industry. The questionnaire consisted of 26 issues and on the behalf of responses obtained from 127 firms; all issues were classified in five main categories which are given as following: -
Customer's issues; Organizational issues; Supplier issues; Market issues; Top management issues
Authors concluded that market issue is the most crucial factor when it comes to implementation of lean philosophy in Indian conditions where as top management issues got lowest rank in the research.

Daugnoraite & Slaitas (2010) discussed that reverse supply chain is very important and could not be seen as additional costs by the firms and strategies should be developed to consider reverse supply chain. Authors insisted that at present, very less literature is present about the strategies for reverse supply chain therefore is a strong need to explore the strategies for reverse supply chain. Research work aimed at application of lean and agile concepts into reverse supply chain along with the impetus and obstacles in the employment of their strategies. To achieve this 13 interviews were taken at 4 firms and it was concluded that a combination of both the strategies known as 'Leagile' should be implemented to obtain good results.

Nordin et al. (2010) carried out research work to study the level of implementation of lean manufacturing techniques in Malaysian automobile industry. For this purpose, a questionnaire was prepared which was sent to 60 Malaysian automotive component manufacturing firms. From the feedback obtained, it was concluded that Kaizen and 5s are mainly implemented lean practices where as cellular manufacturing and supplier involvement in the design practice are the least adopted lean practices. Continuous improvement policy of the firms was found to be the main driving force in the implementation of lean philosophy followed by the customer focus. Further lack of understanding of lean practices was identified as the main barrier in the implementation of lean manufacturing philosophy.

Eswaramoorthi et al. (2011) discussed that lean manufacturing has established survival strategy for many companies across the globe but in India more research has to be done to find out the effect of lean principles on the variety of industries. Research work aimed at the evaluation of lean practices and their extent to which they are applied in Indian machine tool sector. Authors derived 36 lean practices through literature survey and then studied their application in Indian machine tool sector and used SPSS software tool for the statistical calculations on the data received from survey. Survey was done with the help of questionnaire which was validated on the basis of responses obtained from many core machine tool companies and the findings concluded that the lean practices are still not employed abundantly in the Indian machine tool industry and it is in the beginning stage.

Singh et al. (2011) proposed that Value stream mapping is a lean tool which represents the production process visually and it takes the account of both value adding and non value adding activities. Authors mentioned that manufacturing operations can be classified into three categories given as Non value adding activities, Necessary but non value adding activities and Value adding activities. VSM was applied on a small Indian manufacturing firm and after the preparation of present state map and future state map, significant reduction in the total inventory as well as work in process were observed along with the reduction of cycle time, change over time and total lead time.

1.2 Formulation of the survey questionnaire: Being a survey research work, it was needed that the survey questionnaire should be planned carefully. The questionnaire was such formulated that it covers all the topics which are needed to be explored and yet it was kept as simple as possible so that it can encourage the respondent to fill it properly. Clear instructions were provided in the covering electronic mail about the procedure of filling and last date for response. Along with that electronic mail address was also provided to seek help if any problem arises during the fill-up process of the questionnaire. The questionnaire was composed of 4 parts which are discussed below:-

Part A of the questionnaire consists of company's information. In it various questions which could reveal company's basic information are asked. These questions are intended to provide information of the following:-
Name of the company; Type of industry; Turnover of company; Various products manufactured by company; No of employees working in the company; Years of establishment; Name and designation of the respondent.

Part B consists of 3 questions consisting of a total of 34 lean practices, asked on a 5 point likert scale which are intended to explore various lean practices being employed in Indian industries based on the following classification:-
Process and equipment; Manufacturing planning and control; Human Resource

Part C of the questionnaire consists of 3 questions consisting of 28 competitiveness parameters, asked on a 5 point likert scale which are intended to explore the competitiveness advantage of the implementation of lean practices .These parameters are classified as follows:-
Parameters related to business /finance performance; Parameters related to equipment and process; Parameters related to human behavior

Part D of the questionnaire consists of a box in which companies are requested to give themselves rating of lean implementation out of 100 points along with the remarks.

1.3 Distribution and retrieval of questionnaire: To get accurate results, it was needed that the specially designed survey questionnaire should be sent to a large no of Indian industries of every type. For this reason it was planned that the questionnaires would be sent by electronic mail because it is a far quick method of getting responses when time is a constraint. The survey questionnaire was sent to colleagues working in any type of Indian industry and they were requested to forward the electronic mail further to all of their contacts. Thus it was ensured that the specially formulated survey questionnaire could reach to variety of Indian industries in a short period of time. To get the job done, reminder mails were sent to first stage respondents and further some of them were convinced by phone calls. To eliminate the hesitation of companies, they were assured in the cover letter that the data provided by them will not be misused and will be used for research work only and their anonymity will be maintained. Respondents were given a time of two weeks to fill and return the questionnaire and they were requested to ask for any problem which arises during the filling of questionnaire. These problems were solved as soon as possible by giving immediate response to the mails. In the previously fixed time of two weeks a total of 31 filled questionnaires were received from different kind of Indian industries.

1.4 Analysis of received questionnaires: A total of 31 responses were received from different Indian industries. This data was sorted out manually as well as using software tool SPSS.The survey questionnaire was formulated with 34 lean practices and 28 competitiveness performance parameters which could give insight of a company. However most of these lean practices and competitiveness parameters were similar as well as logically connected to each other and could be formed as bundles but if it would have been done in questionnaire, response rate would have been decreased as it is always wise to ask questions on a wide scale so that the chances of accurate results are increased.

2.1 INTERPRETATIONS OF CORRELATION RESULTS

Various researchers have taken individual lean practices as bundles and they have shown that taking lean practices as bundles further improve the efficiency rather than utilizing lean practices at individual level. However in the questionnaire, lean practices were taken as individual along with competitiveness measures but finally they are grouped in small groups containing practices which are similar and logically connected to each other. They are also given short names from variable A to variable k so that they can be used for easy data interpretation .Similarly individual competitiveness parameters are taken together in groups called cumulative performance parameters and they are named from variable L to variable U. List of lean bundles as variables is shown in table 2.1.1.

Table 2.1.1: List of lean bundles as variables

Variables	Lean bundle	Individual lean practices
A	Group technology	Cellular manufacturing Group technology
B	Inventory management	JIT 2 bin auto replenishment system Pull system Lot size reduction Inventory management Supply chain management
C	Value stream	Simulation Value stream mapping Takt time
D	Human resource	Cross functional teams Human resource management 5s Workplace organization
E	Quality	Zero defects Poka yoke Autonomation Andon Total quality management Standardized work Visual management Production stop policy
F	Maintenance	Preventive maintenance Total productive maintenance
G	Agile manufacturing	Agile manufacturing
H	Continuous Improvement	Kaizen Continuous improvement program
I	Setup time reduction	Cycle time reduction SMED Setup time reduction
J	Production smoothening	Single piece flow Production smoothening
K	Scrap reduction	Scrap reduction

All the variables which are similar and logically connected are grouped together as shown in the table 2.1.2.

Table 2.1.2: List of cumulative competitiveness parameters

Variables	Cumulative Competitiveness Parameters	Individual competitiveness measures
L	Parameters related to productivity	Increase in productivity Increase in market share Increase in turnover
M	Parameters related to operational performance	Decrease in manufacturing cost Increase in sales per employee Decrease in total cost of production Increase in return on sales Increase in capacity utilization
N	Parameters related to Finance	Increase in annual sales in rupees Increase in Growth rate in rupee sales Increase in growth rate in unit sales Increase in profit

O	Parameters related to return on capital	Increase in return on assets Increase in return on investments
P	Parameters related to customer satisfaction	Increase in customer return rates Increase in customer satisfaction Decrease in delivery time
Q	Parameters related to equipment efficiency	Decrease in manufacturing cycle time Decrease in changeover time Increase in flexibility in production
R	Parameters related to inventory reduction	Decrease in inventory Decrease in work in progress
S	Parameters related to defect rate	Decrease in waste/rework decrease in defects
T	Parameters related to equipment inability	Decrease in time the machines are damaged Decrease in equipment failure rate
U	Parameters related to employees	Increase in labor productivity Increase in employee satisfaction

After grouping together all the individual lean practices all the lean bundles are named as variables A-K and then put into SPSS software tool. Software produced mean and standard deviation tables for these lean bundle groups which are shown in table 2.1.3.

Table 2.1.3: List of mean of various lean practice bundles as variables

Variables	Lean practice bundle	Mean	Std. Deviation	N
H	Continuous Improvement	3.58	1.06	31
K	SCRAP REDUCTION	3.55	1.06	31
D	Human resource	3.50	0.62	31
F	maintenance	3.25	0.83	31
A	Group technology	3.23	0.94	31
E	Quality	3.14	0.48	31
I	Setup time reduction	3.00	0.86	31
B	Inventory management	2.80	0.45	31
C	Value stream	2.68	0.91	31
J	Production smoothening	2.66	0.86	31
G	Agile manufacturing	2.39	1.12	31

All the lean bundles are arranged in descending order in figure 2.1.4 Lean bundle receiving highest mean is taken on top most position and similarly all the lean bundles are represented by horizontal bars. The length of bars denotes the mean of that identity. From figure 2.1.4 it can be seen that continuous improvement bundle got highest mean which means it is highly practiced as lean bundle among all the lean practices. Agile manufacturing is at lowest position in figure 2.1.4 which means that agile manufacturing is lowest use lean bundle in Indian industries

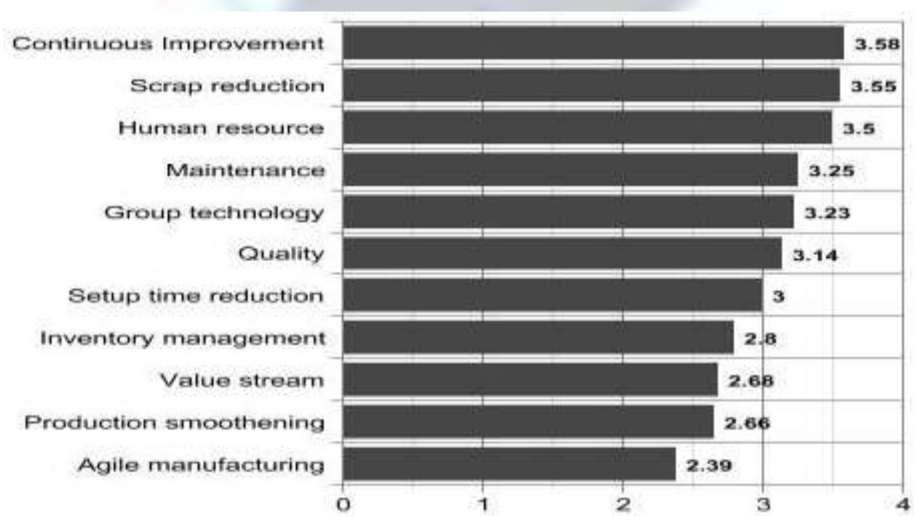

Figure 2.1.4: Bar diagram showing mean of different lean practice bundles.

Cumulative lean parameters were also fed to the software and were given name from variable L-K. From the table 2.1.5 received from SPSS software tool figure 2.1.6 is constructed in which various cumulative competitiveness parameters are arranged in descending order.

Table 2.1.5: List of mean of various cumulative competitiveness measures as variables

Variables	Cumulative Competitiveness Measures	Mean	Std. Deviation	N
N	Parameters related to Finance	3.69	0.56	31
U	Parameters related to employees	3.65	0.67	31
L	Parameters related to productivity	3.60	0.42	31
P	Parameters related to customer satisfaction	3.44	0.61	31
Q	Parameters related to equipment efficiency	3.40	0.70	31
M	Parameters related to operational performance	3.33	0.58	31
S	Parameters related to defect rate	3.29	0.85	31
T	Parameters related to equipment inability	3.16	0.77	31
O	Parameters related to return on capital	3.11	1.15	31
R	Parameters related to inventory reduction	3.03	0.67	31

From figure 2.1.6 it can be seen that parameters related to finance received highest score in mean table 2.1.5 which means these parameters are highly benefited from lean practices. Similarly it can be seen that parameters relating inventory reduction received lowest score which implies that reduction in inventory is least benefited from the adoption of lean practices in Indian industries.

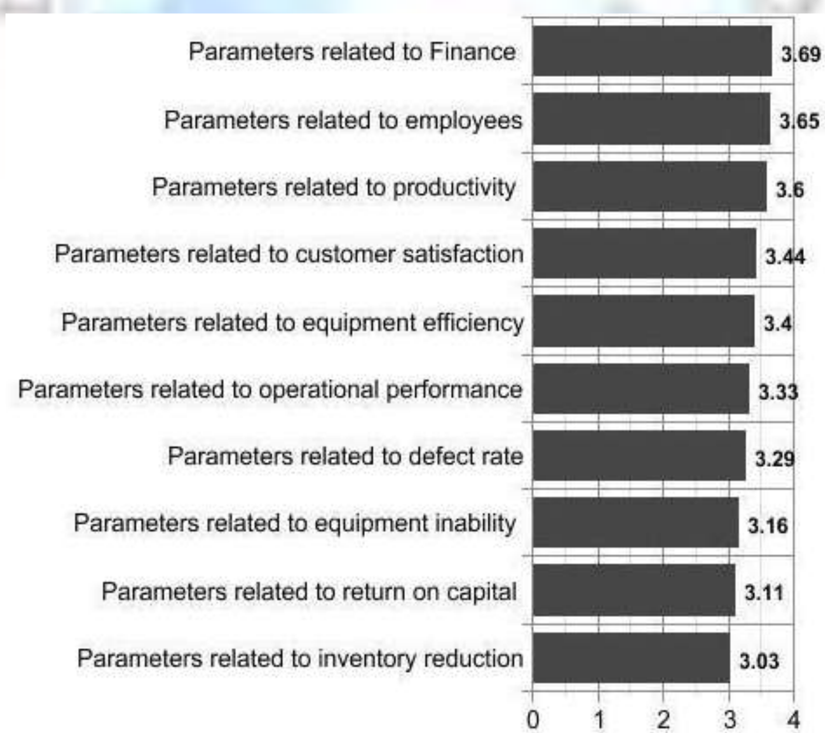

Figure 2.1.6: Bar diagram showing mean of cumulative competitiveness measures.

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3.1: INTERPRETATION OF CORRELATION RESULTS

A correlation is useful when the relationship between two (or more) normally distributed interval variables is to be analyzed. The correlation table 3.2.1 displays Pearson correlation coefficients, significance values, and the number of cases (N).

Pearson's correlation coefficient value (r)

Pearson's correlation coefficient assumes that each pair of variables is bi-variate normal and it is a measure of linear association. Two variables can be perfectly related, but if the relationship is not linear, Pearson's correlation coefficient is not an appropriate statistic for measuring their association. The Pearson correlation coefficient (r) for short is a measure of the degree of linear relationship between two variables. The sign of the correlation coefficient (+, -) defines the direction of the relationship, either positive or negative. A positive correlation coefficient means that as the value of one variable increases, the value of the other variable increases; as one decreases the other decreases. While the negative sign indicates that if the value of one variable increases the other variable will decrease. The absolute value of the correlation coefficient indicates the strength, with larger absolute values indicating stronger relationships. The values of the correlation coefficient (r) range from -1 to 1,

$$-1.00 \le r \le +1.00$$,

With -1 indicating a perfect negative correlation, +1 indicating a perfect positive correlation, and 0 indicating no correlation at all. The Range of 'r' is defined as:

$r = -1$	Perfect negative relation
$-1 < r < -0.5$	Strong negative relation
$-0.5 < r < 0$	Weak negative relation
$r = 0$	Means no relation
$0 < r < 0.5$	Weak positive relation
$0.5 < r < 1$	Strong positive relation
$r = 1$	Perfect positive relation

COMPUTATIONAL TECHNIQUE FOR PEARSON CORRELATION COEFF. (r)

For X and Y the two sample variables that need to be correlated,
X = Mean of all responses of X variable.
Y = Mean of all responses of Y variable.
The value of for Pearson correlation coefficient, r can be calculated by following formula:-

$$r = \frac{\sum_{i=1}^{N} z_X z_Y}{N-1}$$

$$z_X = \frac{X - \bar{X}}{s_X}$$

$$z_Y = \frac{Y - \bar{Y}}{s_Y}$$

Where, N= Sample Size
S_X = Sample standard deviation of X variable.
S_Y = Sample standard deviation of Y variable.

Significance level

The significance of each correlation coefficient is also displayed in the correlation table 3.2.1 The significance level (or p-value) is the probability of obtaining results as extreme as the one observed. If the significance level is very small (less than 0.05) then the correlation is significant and the two variables are linearly related. If the significance level is relatively large (for example, 0.50) then the correlation is not significant and the two variables are not linearly related. We can select two-tailed or one-tailed probabilities. If the direction of association is known in advance, select 1-tailed otherwise, select 2-tailed.

Sample size (n)

This signifies the number of cases that were used in the correlation.

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3.2 CORRELATION RESULTS OF LEAN BUNDLES WITH CUMULATIVE COMPETITIVENESS PARAMETERS

Correlation table 3.2.1 was taken as output from SPSS software tool and which is represented in this section. As discussed earlier, the table contains the value of Pearson's coefficient 'r' .higher the value of this coefficient higher will be the relationship between two variables.

Table 3.2.1: Correlation table of lean bundles and cumulative competitiveness parameters

Correlations

		A	B	C	D	E	F	G	H	I	J	K	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**
A	r	1	.633**	.381*	.514**	.772**	.411*	.200	.535**	.595**	.697**	.642**	**-.189**	**.177**	**.310**	**-.325**	**.541****	**.539****	**.359***	**.311**	**.248**	**.171**
	t		.000	.034	.003	.000	.022	.280	.002	.000	.000	.000	.308	.340	.090	.075	.002	.002	.047	.089	.178	.359
B	r	.633**	1	.326	.245	.664**	.430*	.447*	.293	.563**	.607**	.479**	**-.189**	**.216**	**.389***	**-.157**	**.515****	**.484****	**.561****	**.518****	**.363***	**.208**
	t	.000		.074	.185	.000	.016	.012	.110	.001	.000	.006	.310	.244	.031	.400	.003	.006	.001	.003	.045	.262
C	r	.381*	.326	1	.000	.227	.538**	.029	-.221	-.061	.217	-.040	**.123**	**.162**	**.236**	**.100**	**.297**	**.023**	**.045**	**-.083**	**.061**	**.171**
	t	.034	.074		.999	.219	.002	.879	.233	.743	.240	.829	.509	.384	.201	.593	.105	.904	.809	.657	.745	.358
D	r	.514**	.245	.000	1	.646**	.313	.324	.633**	.536**	.288	.392*	**.064**	**.106**	**.197**	**-.197**	**.269**	**.385***	**.160**	**.024**	**.035**	**.259**
	t	.003	.185	.999		.000	.086	.075	.000	.002	.116	.029	.732	.570	.289	.287	.144	.032	.390	.900	.852	.160
E	r	.772**	.664**	.227	.646**	1	.461**	.433*	.503**	.582**	.449*	.618**	**-.074**	**.119**	**.336**	**-.176**	**.416***	**.544****	**.413***	**.419***	**.187**	**.214**
	t	.000	.000	.219	.000		.009	.015	.004	.001	.011	.000	.691	.524	.065	.344	.020	.002	.021	.019	.313	.249
F	r	.411*	.430*	.538**	.313	.461**	1	.342	.128	.165	.234	.179	**.304**	**.364***	**.436***	**-.214**	**.441***	**.360***	**.435***	**.345**	**.366***	**.455***
	t	.022	.016	.002	.086	.009		.060	.492	.375	.206	.335	.096	.044	.014	.247	.013	.047	.014	.057	.043	.010
G	r	.200	.447*	.029	.324	.433*	.342	1	.467**	.570**	.471**	.435*	**-.017**	**.054**	**-.070**	**-.191**	**.127**	**.496****	**.495****	**.263**	**.333**	**.056**
	t	.280	.012	.879	.075	.015	.060		.008	.001	.007	.015	.928	.773	.707	.304	.495	.005	.005	.153	.067	.765
H	r	.535**	.293	-.221	.633**	.503**	.128	.467**	1	.748**	.553**	.554**	**-.128**	**.113**	**.092**	**-.637****	**.105**	**.560****	**.326**	**.213**	**-.017**	**.088**
	t	.002	.110	.233	.000	.004	.492	.008		.000	.001	.001	.493	.546	.622	.000	.574	.001	.074	.250	.930	.636
I	r	.595**	.563**	-.061	.536**	.582**	.165	.570**	.748**	1	.762**	.588**	**-.323**	**.215**	**.035**	**-.360***	**.382***	**.672****	**.503****	**.350**	**.321**	**.097**
	t	.000	.001	.743	.002	.001	.375	.001	.000		.000	.001	.077	.245	.854	.047	.034	.000	.004	.054	.079	.605
J	r	.697**	.607**	.217	.288	.449*	.234	.471**	.553**	.762**	1	.558**	**-.420***	**.177**	**-.127**	**-.338**	**.469****	**.493****	**.482****	**.240**	**.413***	**-.056**
	t	.000	.000	.240	.116	.011	.206	.007	.001	.000		.001	.019	.341	.495	.063	.008	.005	.006	.193	.021	.764
K	r	.642**	.479**	-.040	.392*	.618**	.179	.435*	.554**	.588**	.558**	1	**-.296**	**.076**	**.152**	**-.366***	**.290**	**.675****	**.702****	**.260**	**.277**	**.165**
	t	.000	.006	.829	.029	.000	.335	.015	.001	.001	.001		.106	.684	.415	.043	.113	.000	.000	.157	.132	.375

L	r	-.189	-.189	.123	.064	-.074	.304	-.017	-.128	-.323	-.420*	-.296	1	.001	.388*	.189	.047	-.127	-.411*	-.166	-.400*	.273
	t	.308	.310	.509	.732	.691	.096	.928	.493	.077	.019	.106		.994	.031	.308	.804	.495	.022	.372	.026	.137
M	r	.177	.216	.162	.106	.119	.364*	.054	.113	.215	.177	.076	.001	1	.294	.017	.398*	.374*	.220	.110	.236	.496**
	t	.340	.244	.384	.570	.524	.044	.773	.546	.245	.341	.684	.994		.109	.926	.026	.038	.234	.555	.202	.005
N	r	.310	.389*	.236	.197	.336	.436*	-.070	.092	.035	-.127	.152	.388*	.294	1	-.183	.471**	.329	.171	.357*	.041	.684**
	t	.090	.031	.201	.289	.065	.014	.707	.622	.854	.495	.415	.031	.109		.325	.007	.071	.357	.049	.826	.000
O	r	-.325	-.157	.100	-.197	-.176	-.214	-.191	-.637**	-.360*	-.338	-.366*	.189	.017	-.183	1	-.131	-.288	-.393*	-.221	-.059	-.076
	t	.075	.400	.593	.287	.344	.247	.304	.000	.047	.063	.043	.308	.926	.325		.482	.117	.029	.233	.753	.686
P	r	.541**	.515**	.297	.269	.416*	.441*	.127	.105	.382*	.469**	.290	.047	.398*	.471**	-.131	1	.529**	.302	.369*	.396*	.522**
	t	.002	.003	.105	.144	.020	.013	.495	.574	.034	.008	.113	.804	.026	.007	.482		.002	.098	.041	.027	.003
Q	r	.539**	.484**	.023	.385*	.544**	.360*	.496**	.560**	.672**	.493**	.675**	-.127	.374*	.329	-.288	.529**	1	.651**	.435*	.375*	.513**
	t	.002	.006	.904	.032	.002	.047	.005	.001	.000	.005	.000	.495	.038	.071	.117	.002		.000	.014	.038	.003
R	r	.359*	.561**	.045	.160	.413*	.435*	.495**	.326	.503**	.482**	.702**	-.411*	.220	.171	-.393*	.302	.651**	1	.449*	.654**	.248
	t	.047	.001	.809	.390	.021	.014	.005	.074	.004	.006	.000	.022	.234	.357	.029	.098	.000		.011	.000	.179
S	r	.311	.518**	-.083	.024	.419*	.345	.263	.213	.350	.240	.260	-.166	.110	.357*	-.221	.369*	.435*	.449*	1	.396*	.359*
	t	.089	.003	.657	.900	.019	.057	.153	.250	.054	.193	.157	.372	.555	.049	.233	.041	.014	.011		.027	.047
T	r	.248	.363*	.061	.035	.187	.366*	.333	-.017	.321	.413*	.277	-.400*	.236	.041	-.059	.396*	.375*	.654**	.396*	1	.163
	t	.178	.045	.745	.852	.313	.043	.067	.930	.079	.021	.132	.026	.202	.826	.753	.027	.038	.000	.027		.382
U	r	.171	.208	.171	.259	.214	.455*	.056	.088	.097	-.056	.165	.273	.496**	.684**	-.076	.522**	.513**	.248	.359*	.163	1
	t	.359	.262	.358	.160	.249	.010	.765	.636	.605	.764	.375	.137	.005	.000	.686	.003	.003	.179	.047	.382	

**. Correlation is significant at the 0.01 level (2-tailed),

*. Correlation is significant at the 0.05 level (2-tailed),

r= Pearson Correlation Co-eff.

From correlation table 3.2.1 we can see that Variable A has strong positive relationship with variables P,Q and R respectively which can be interpreted as lean bundle associated with variable A has strong relationship with competitiveness parameters associated with variables P,Q and R. It means Group technology bundle of lean practices results in better customer satisfaction, equipment efficiency and inventory reduction. Also variable A has negative relationship with variable O which can be interpreted as due to the capital investment needed in better and multifunctional equipments, group technology bundle becomes expensive when related to return on capital parameters.

Variable B has strong positive relationship with variables R, which means inventory management lean bundle, gives high results in terms of parameters related to inventory reduction. It also has strong relationship with Q, S and P respectively which means Inventory management bundle also gives benefit in terms of parameters related to equipment efficiency ,defect rate and customer satisfaction.

Variable C do not have much high relationship with all the parameters yet it has highest positive relation with variable N which means value stream bundle is not popularly adopted in Indian industries. Variable D has highest positive relationship with variable Q which means that human resource bundle performs well in terms of enhanced equipment efficiency which interprets that employing efficient employees, equipment efficiency will be greatly increased. Variable E has strong positive relationship with Q and P which means that quality bundle serves well in terms of customer satisfaction and equipment efficiency Variable F has strong positive relationship with almost all cumulative competitiveness parameters except O which means that maintenance bundle helps in all fields of competitiveness improvement except return on capital. Variable G has strong positive relationship with Variable Q and R which means that agile manufacturing bundle performs well in terms of enhanced equipment efficiency and inventory reduction. Similarly it can be interpreted by the table 3.2.1 that continuous improvement bundle has good relationship with equipment efficiency and negative relationship with return on capital parameters. Setup time reduction bundle has shown strong positive relationship with equipment efficiency which means that reduction of setup time directly means increased equipment efficiency. Production smoothening bundle has strong relationship with inventory reduction, equipment efficiency and customer satisfaction. Scrap reduction shows strong positive relationship with equipment efficiency and inventory reduction.

From correlation table 3.2.1, table 3.2.2 has been prepared based on the number of best positive relations of lean bundles with cumulative competitiveness parameters.

Table 3.2.2: List of number of highest positive relationships of various lean bundles

No of highest positive relationships	Lean bundles
7	Maintenance
6	Inventory management
4	Quality + production smoothening
3	Setup time reduction + Group technology
2	Agile manufacturing + Scrap reduction
1	Continuous Improvement + Human resource
0	Value stream

Table 3.2.2 signifies the lean bundles which are all rounder in enhancing the competitiveness of a firm. Lean bundle present at higher position in this table means that it has benefits in all fields of competitiveness. Table 3.2.3 has also been prepared on the no of strong positive relationship of cumulative competitiveness parameters with lean bundles.

Table 3.2.3: List of number of highest positive relationships of cumulative competitiveness parameters.

No of highest positive relationships	Cumulative competitiveness parameters
10	Parameters related to equipment efficiency
8	Parameters related to inventory reduction
6	Parameters related to customer satisfaction
3	Parameters related to equipment inability
2	Parameters related to defect rate + Parameters related to finance
1	Parameters related to operational performance
0	Parameters related to return on capital + Parameters related to productivity + Parameters related to employees

Higher the position of any cumulative competitiveness parameter, higher is that benefited from various lean bundles. This means that equipment efficiency is mostly benefited from various lean bundles in Indian industries.

CONCLUSION & FINDINGS

Research work has validated some pre-claimed facts of lean manufacturing in Indian industries as well as concluded some new findings also which are being discussed in this chapter. Like always lean manufacturing has also proved its capabilities in this research and it was found that lean manufacturing techniques are beneficial in enhancing the competitiveness of any industry .After rigorous data interpolation and statistical analysis of the responses obtained from 31 different industries, following findings are concluded:-

Finding 1: - Increase in customer satisfaction is found to be the most benefited individual field in context to lean manufacturing followed by increase in profit and increase in productivity.

Finding 2: - Continuous improvement bundle is concluded as the most used lean bundle where as agile manufacturing is concluded as least used lean bundle. It means that mostly individual lean practices are related to continuous improvement philosophy of the organization.

Finding 3: - Cumulative competitiveness parameters related to finance were mostly benefited from the adoption of lean practices where as Cumulative parameters related to inventory reduction are found to be least benefited from the adoption of lean philosophy in Indian industries.

Finding 4: - Lean bundles related to maintenance, inventory management and quality are concluded to have strong correlation with most of the cumulative competitiveness parameters.

Finding 5: - Cumulative parameters related to equipment efficiency, inventory reduction and customer satisfaction are concluded to have strong correlation with most of the lean bundles.

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