Manufacturing Competitiveness through Lean Principles – Analysis of Readiness Level and Comparison in Small and Medium Enterprises by Identification and Modeling the Critical Success Factors

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Abstract— The purpose of this study is to identify the critical success factors influencing lean production in Small and Medium Enterprises. A survey is conducted within the manufacturing organizations of Kerala to find out the current level of Lean practices within the manufacturing organizations in Kerala. The results are then analyzed to understand the relationship between variables. This study helps to determine whether the organizations have the foundation to implement Lean Systems. The competitive market pressures and other issues challenging the survival of small and medium size enterprises have been the motivating factor for conducting this study. Lean manufacturing offers an ideal solution in initiating cost reducing strategies like, the identification and elimination of wastes and also enhancing their productivity and competitiveness.

Index Terms— Lean Production, Lean Readiness level, degree of adoption of lean production principles, Small and medium enterprises, SMEs in Kerala, critical success factors, multiple regression analysis

1 Introduction

Today, the Small and Medium sized Enterprises (SMEs) are getting more focused due to various reasons such as they are the real engine for growth of the Indian economy, provide employment to a large chunk of population, it is breeding ground for entrepreneurs, its considerable contribution to GDP and export earnings, etc. This is the time when the SMEs in India should brace up to face new challenges of the modern times. So, the SMEs have no choice but to improve both in quality and standards as well as costing and pricing to survive.

Lean manufacturing offers an ideal solution in initiating cost reducing strategies like, the identification and elimination of wastes in the entire manufacturing environments and also enhancing their productivity and competitiveness. Lean manufacturing is like taking to a systematic approach for identifying and eliminating waste in operations through continuous improvement for doing everything more efficiently, reducing the cost of operating the system and fulfilling the customers desire for maximum value at the lowest price. The mantra is: lowest inputs for highest output and quality.

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1.1 Objectives

1. Identification and modelling the critical success factors influencing lean production in SMEs
2. To conduct a survey and find out the current level of Lean practices within the manufacturing organizations in Kerala.
3. To analyze the relationship between the factors affecting lean implementation and to develop a mathematical model.
4. To compare the lean readiness level of various groups of organizations

1.2 Scope

The scope of this study is in the premise of lean manufacturing utilisation within the SMEs community who are engaged in the manufacture sector in Kerala.

2 Literature Review

2.1 Lean manufacturing basic concept and definitions

Lean manufacturing is based on finding efficiencies and removing wasteful steps that don't add value to the end product. There's no need to reduce quality with lean manufacturing – the cuts are a result of finding better, more efficient ways of accomplishing the same tasks. The core idea is to maximize customer value while minimizing waste. Simply, lean means creating more value for customers with fewer resources. A lean organization understands customer value and

focuses its key processes to continuously increase it. The ultimate goal is to provide perfect value to the customer through a perfect value creation process that has zero waste.

Lean manufacturing has many definitions associated with it. For the purpose of this study lean manufacturing, was defined as the systematic removal of waste by all members of the organization from all areas of the value stream (Worley, 2004). The value stream is defined as all of the activities that contribute to the transformation of a product from raw material to finished product including design, order taking, and physical manufacture (Womack and Jones, 1996).Waste is any non-necessary activity that does not add value for the customer. Lean production is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability (Rachna Shah, Peter T. Ward, 20007).

2.2 Lean manufacturing and SMEs in India

For manufacturing sector, an enterprise is classified in India as:

a) Small enterprise, if investment in plant and machinery is more than twenty five lakh rupees but does not exceed five crore rupees; or

b) Medium enterprise, if investment in plant and machinery is more than five crore rupees but does not exceed ten crore rupees;

In today's competitive world while many large scale companies have taken initiatives to implement lean in their organizations, small & medium establishments (SMEs) also need to follow the lean thinking and implement the same to achieve their set goals. To meet the challenge of stiff competition and imports from overseas, the Indian SMEs are left with no choice but to take to manufacturing practices that would induce cost effectiveness and improvement in quality standards.

3 METHODOLOGY

This study aims to evaluate that how far the SMEs in Kerala are practicing the principles of Lean manufacturing. The organizations may have implemented or practicing some elements of lean manufacturing in terms of any of the lean tools or any activity that is a part of lean. By evaluating these waste reduction and quality improvement practices, the capability of the organizations to implement lean system can be found out. It also gives an overall picture of the present level of lean readiness among the manufacturing organizations of kerala.

3.1 Measurement framework

The critical success factors which are the key drivers for implementing lean production in Small and Medium Enterprises identified are Top management support and commitment, Employee involvement, Supplier involvement, Customer involvement, Just in time practices and pull production, Process, Resource reduction and TPM. The following four constructs have in this study been recognised as critical success factors underlying the dependent variable Degree of adoption of lean production principles (DOL):

- ✓ Just in time practices and pull production,
- ✓ Process
- ✓ Resource reduction
- ✓ TPM

The CSFs for the DOL were developed based on the literature review focusing on the technical requirements of lean and elements associated with important lean tools.

The factors which are considered as independent variables in this study are;

- ✓ Top Management support and commitment
- ✓ Employee involvement
- ✓ Supplier involvement
- ✓ Customer involvement

The selected independent variables are associated with the lean as a whole philosophy. The literatures suggest that reducing the external variability (supplier and demand) and the strong support of management and employees are important supporting factors of lean manufacturing.

3.2 Instrument for data collection

An online questionnaire was developed to collect data for this exploratory study. The questionnaire consist of 45 questions representing the different variables selected for this study and also required the organization's details and respondent's. The organizational details such as scale of the organization, quality management practices implemented etc were included in the questionnaire to categorise the organizations and conduct further analysis. The instrument was designed in a simple manner so that a production manager / engineer can easily understand and reply in a 5 point scale (strongly agree – 5, agree – 4, neutral -3, disagree- 2, strongly disagree – 1)

3.3 Data collection

The online questionnaire was directly sent to the email id of the organizations or managers requesting them to respond for the survey. The response rate for the survey was very low. Only 36 organizations out of 220 were responded. 6 responses were rejected as they were not complete. 28 complete responses were used for further analysis. Majority of the responses received are from online questionnaire, which shows that online questionnaires are more effective in data collection.

3.4 Analysis model

Multiple linear regression method has been used to model and analyse the relationship between variables in this study. Multiple regression analysis was used to analyse the relationship between a single metric dependent variable and several metric independent variables.

The analysis model of multiple linear regression method was formulated as:

$$Y= \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4$$

Where:

Y= Degree of adoption of lean production principles (dependent variable)

β0 = constant

β1 β2, β3, βn = regression coefficient

X1, X2, X3, X4 = independent variables; Top management support and commitment, Employee involvement, Supplier involvement and Customer involvement respectively

3.5 Hypothesis

H1: At least one of the independent factors has significant influence in implementing lean Production

H2: There exists significant difference in at least one factor of Lean system practises of Small and Medium sized firms

H3: There exists significant difference in at least one factor of Lean System practice of Small scale firms having ISO 9001 certification and not having ISO certification.

4 RESULTS

4.1 Classification of respondents by type of company

The respondents were classified based on the scale of the organization and based on ISO 9001 certification. Based on the scale, the organizations are classified as Small and Medium firms. Based on the ISO certifications the organizations are classified in to ISO 9001 Certified and non ISO firms. Out of the 28 responses, 7 organizations were from medium scale organizations and 21 from small scale organizations. All medium scale organizations were ISO 9001 certified and 13 out of 21 small scale organizations were ISO 9001 certified organizations.

4.2 The level of implementation of CSFs for lean implementation

The mean scores of each item of the survey questionnaire are shown in table 1.

Table 1: Mean of each item of the survey questionnaire

Factors	*Items*	*Mean*	*Overall mean*
F1 Top Management support and commitment	F11	3.68	3.19
	F12	2.54	
	F13	3.25	
	F14	3.32	
	F15	3.11	
	F16	3	
F2 Employee involvement	F21	3.96	3.15
	F22	3.71	
	F23	3.46	
	F24	3.43	
	F25	3.29	
F3 Supplier involvement	F31	2.39	3.17
	F32	3.43	
	F33	3.43	
	F34	3.39	
	F35	3.89	
	F36	3.68	
	F37	3.61	
F4 Customer involvement	F41	3.39	2.87
	F42	2.86	
	F43	2.36	
	F44	2.93	
	F45	2.82	
F5 Just in time practices and pull production	F51	2.79	2.99
	F52	3.04	
	F53	3.11	
	F54	2.25	
	F55	3.57	
F6 Process	F61	3.32	3.15
	F62	3.68	
	F63	3.18	
	F64	2.96	
	F65	3.04	
	F66	3.07	
	F67	3.25	
	F68	2.71	
F7 Resource reduction	F71	3.25	3.15
	F72	3.21	
	F73	3.21	
	F74	2.82	
F8 TPM	F81	3.75	3.81
	F82	3.75	
	F83	4.14	
	F84	3.61	
	F85	3.82	

4.3 Internal consistency analysis

Using the SPSS reliability analysis procedure, an internal consistency analysis was performed separately for the items of each critical factor. Cronbach's Alpha is commonly used for this purpose as shown in Table 2. The Cronbach's Alpha value for the total scale was 0.929, indicating a high degree of internal consistency among the items on the scale.

Table 2: Results of reliability test of variables

	No. of items	Items Deleted	Cronbachs Alpha
F1	6	None	.754
F2	5	None	.764
F3	7	None	.715
F4	5	None	.796
DOL	4	None	.801

The value of each variable, as measured by each statement on the scale of 1 to 5, is computed using the reliability analysis in SPSS and the alpha values range from 0.715 to 0.801, which indicates an internal consistency with the alpha value of more than 0.70, so no items were dropped

Table 3: Factors applicable to Degree of Adoption of lean production principles

	No. of items	*Items Deleted*	*Cronbachs Alpha*
F5	5	None	.734
F6	8	None	.736
F7	4	None	.775
F8	5	None	.726

4.4 Regression analysis

Regression analysis was conducted for estimating the relationships among variables. The table 4 shows the result of regression analysis between depended variable and the 4 independent variables. Result of the multiple regression analysis toward degree of adoption of lean production principles as the function of the implementation of Lean production showed F= 31.137, significant at the level p = 0.001.The R2 value .844indicates a good fit of the model. By using the significant level α = 0.05, it means that four lean variables viz. Top management support and commitment, employee involvement, Supplier involvement and Customer involvement have influence to the degree of adoption of lean production principles or lean implementation.

In hypothesis testing, since the p value is less than .05 the hypothesis H1 is not rejected. The regression analysis shows a significant influence of the independent variables Top management commitment, Supplier Involvement and Employee involvement with the dependent variable Degree of Adoption of lean production principles (DOL). The variable customer involvement shows less influence on DOL as the significance value is greater than .05.

Table 4: Results of regression analysis

Model	*Unstandardized Coefficients*		*t*	*Sig.*
	B	*Std. Error*		
(Constant)	.752	.243	3.097	.005
F1	.235	.094	2.493	.020
F2	.321	.100	3.206	.004
F3	.275	.111	2.478	.021
F4	-.039	.066	-.591	.560

The regression model can be symbolically represented as: Degree of Adoption of Lean principles = .752 + .235 (Top management commitment) + .321 (Employee Involvement) + .275 (Supplier involvement) - .039 (Customer Involvement)

4.5 t test

The Independent-Sample t-test allows us to test whether a two sample means are significantly different from each other. In order to run the t-test, it was necessary to decide whether equal variance could be assumed. To this end, Levene's test was carried out for the four constructs to see whether the p-value was greater or less than 0.05. The test was conducted for the small Vs medium scale firms and for small scale firms having ISO9001 certified Vs non-ISO9001 firms.

Table 5: Levene's test results

	Small and Medium		*ISO 9001and NON ISO*	
	F	*Sig.*	*F*	*Sig.*
DOL	.87	.35	1.15	.29
F1	1.5	.22	.03	.85
F2	.13	.71	.71	.40
F3	1.33	.25	.12	.72

Results of Levenes test shown in table 5 indicate the p value is greater than .05 for all cases. So we can assume equal variances and we can use standard t test procedures.

From the independent sample t test among the small and medium sized firms shown in table 6, we can see a significant difference in mean values only for degree of adoption of lean production principles. The mean values of the different variables lies in a range of 3.4 to 3.63 for medium scale organizations where as for small scale organizations the mean values ranges from 3.03 to 3.16. These shows that the medium scale organization have a greater degree of lean readiness.

Table 6: T test results; Small scale Vs Medium scale firms

	Mean		*t*	*Sig.*
	Small (N=21)	*Medium (N=7)*		
DOL	3.16	3.63	-2.31	**.029**
F1	3.07	3.57	-1.63	.114
F2	3.03	3.48	-1.62	.116
F3	3.10	3.40	-1.21	.237

Table 7: T test results; ISO 9001 Vs non ISO firms

	Mean		*t*	*Sig.*
	ISO (N=13)	*Non ISO (N=8)*		
DOL	3.35	2.84	-3.14	**.005**
F1	3.32	2.66	-2.46	**.024**
F2	3.23	2.72	-1.88	.075
F3	3.31	2.75	-2.59	**.018**

The independent sample t test among Small scale organizations having ISO 9001 certification and non ISO organizations shown in table 7 indicates a significant difference in Degree of adoption of lean production principles, Top management commitment and Supplier involvement. Whereas the employee involvement doesn't show any significant differences, which means both the organizations having ISO and non ISO are equally weak in employee involvement in their organizations. The mean values of the different variables lies in a range of 3.23 to 3.35 for ISO certified organizations where as for non ISO organizations the mean values ranges from 2.66 to 2.84. Clearly from the results we can see that, implementing ISO 9001 QMS are supportive to implement Lean Systems and helps to improve the lean readiness level.

From the t test of small and medium scale organizations, as the p value of DOL is less than .05 the hypothesis H2 is not rejected. Also from the t test of ISO and non ISO organizations, as the p value of DOL, Top management commitment and

supplier involvement are less than .05, hypothesis H3 is also not rejected. Summary hypothesis testing results are shown in table 8.

Table 8 Hypothesis test results

Hypothesis	*Accept or Reject*
H1: At least one of the independent factors has significant influence in implementing lean Production	Accept
H2: There exists significant difference in at least one factor of Lean system practises of Small and Medium sized firms	Accept
H3: There exists significant difference in at least one factor of Lean System practice of Small scale firms having ISO 9001 certification and not having ISO certification.	Accept

5 Conclusion

5.1 Summary

The first objective set out to identify the key drivers for implementing lean manufacturing within SMEs have been achieved by conducted a critical analysis of published work within the subject of lean manufacturing and its related attributes. The different lean manufacturing techniques/methods and their applicability was included in the identification process of the key drivers for lean implementation.

The second objective, to conduct survey and find out the current level of Lean practices within the manufacturing organizations in Kerala was completed. A questionnaire was developed using the factors that are to be used to assess lean manufacturing in a company. A set of 45 questions were used to collect data for the dependent and independent variables. The response rate for the survey was very low due to various reasons such as the organizations don't want to disclose their details, non availability of the right person to answer the questionnaire, negative attitude towards quality improvement practices etc. The collected data is then checked for reliability and an overall alpha of .929 was obtained. The mean score of the CSFs ranges from 2.87 to 3.81 which shows the organizations have to improve a lot for becoming lean.

A regression model was developed to analyze the relationship between the factors affecting lean implementation, thus achieving the third objective. The regression analysis indicates a significant relation among the degree of adoption of lean production principles and the top management commitment, employee involvement, supplier involvement and customer involvement.

To compare the means of various groups of independent sample t test was carried out between (1) small and medium sized firms and (2) small scale firms with ISO 9001 implemented and NON ISO firms. The comparison shows significant differences in the mean of the two groups.

5.2 Limitations and scope for future research

One of the limitations of this study is the small sample size; we faced difficulty in convincing the organizations to participate in the survey. The low response rate for the survey was due to various reasons such as the organizations don't want to disclose their details, non availability of the right person to answer the questionnaire, negative attitude towards quality improvement practices etc. Also the findings of this study are limited in terms of generalizability to the SMEs of Kerala as the participated organizations are mainly from three districts.

For further future researches, a valid benchmark can be investigated by applying this framework to the organizations successfully implemented lean. The critical success factors identified can be used to find out the Lean readiness level of a particular sector of industry. Further research is required to find out he reasons for the negative regression coefficient of customer involvement and its less significance in regression model.

5.3 Conclusions

The nine critical success factors which are the key drivers for implementing lean production in Small and Medium Enterprises identified are Top management support and commitment, Employee involvement, Supplier involvement, Customer involvement, Just in time practices and pull production, Process, Resource reduction and TPM. The attributes Just in time practices and pull production, Process, Resource reduction and TPM represents the dependent variable Degree of adoption of lean production principles whereas the other four attributes; op management support and commitment, Employee involvement, Supplier involvement, Customer involvement are independent variables. The regression analysis shows that there exists a significant influence of the independent variables with the dependent variables. All the critical success factors excluding the customer involvement have a positive influence on the successful implementation of lean production in SMEs. The organizations can use the questionnaire to evaluate the lean performance of their organizations prior to lean implementation, during implementation and post implementation to assess their current level of leaness. This helps them to find out the areas they have to improve and the results of their implementation activities. The lean readiness level assessment also helps them to; obtain a clear picture of the business drivers that will support or block the lean initiatives, develop a plan that identifies what the company needs to accomplish, to integrate and sustain lean success and reduce the cost of implementing lean by identifying and addressing potential mental and cultural barriers

The medium sized organizations have greater readiness towards lean, as they more resources compares to the small organizations. Also the medium scale organizations have a wider customer community and other marker pressures have forced them to implement at least some quality management practices to become competitive. The small scale organizations are comparatively less competitive and they ignore the quality management and waste reduction techniques. Most of the organizations don't care about understanding the customer re-

quirements and delivering value to customers. The study shows that the organizations implemented ISO 9001QMS are performing better and have comparatively higher degree of leaness.

The road blocks faced by the organizations while implementing any quality management initiatives are Poor ability to gather, process, store and distribute information, Shortage of skilled manpower, financial constraints and lack of marketing set up, Heavy dependence on CEO for each and every activity in the company, Difficult to maintain the continuity in absence of support. Additionally, understanding and awareness of the benefits and principles of Lean production have been found to be very low, and knowledge of Lean production is missing in SMEs.

The SMEs have to overcome the limitations and give serious importance to various quality management systems like lean production to become more productive and improve their competency. The framework developed here helps organizations to improve their productivity by reducing waste and delivering value to the customer.

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