



RESEARCH ARTICLE

Facilitating Lean Manufacturing Systems Implementation: Role of Top Management

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Abstract

The requirement of Lean Manufacturing has increased due to waste and subsequent increase in cost of the manufacturing goods. Five variables of lean manufacturing system implementation have been identified from the literature and subsequent discussions with experts' opinions. Classification of the variables has been carried out based upon the Mean, Variance and Kurtosis values. Relationships of variables have been carried out through the hypothesis testing. Top Management commitment have strong relationship with the variables (capability and competence of the sales network, Quality of the human resources, Customer involvement in quality program, Collaborative decision making) and the hypothesis test of the variables proved the relationship among the variables. The conclusions so drawn may be further modified to apply in real situation. Clear understanding of relationship among these variables will help organizations to prioritize and manage these variables more effectively and efficiently to get more speed in lean implementation. The hypothesis will help to understand the internal dependencies of the variables to get effective results in lean implementation.

Keywords: Hypothesis testing, Lean manufacturing system, Top management Commitment.

Introduction

Lean Manufacturing System has emerged as an imperative area of research in Indian perspective. It is a manufacturing system that's provides the flexibility required to satisfy the rapidly changing demands of customers. Whenever operates by the cost reduction principle, meets quality cost and delivery requirements, and wants to eliminate all waste from the customer's value stream surely need to learn about lean to succeed in the market [1]. The purpose of this study is to investigate the approach of adopting lean, the tools and techniques implemented, the changes in the organizations, the problems encountered as well as the lessons learnt. This paper describes the results and findings of four industrial case studies conducted in different electrical and electronics companies in Malaysia. Interviews were conducted with the key personnel to answer some issues which were crucial in this study. Comparisons and discussion were made among the case companies. One of the key findings obtained is that people in the organization should possess the lean mindset and act in the lean way

in order to make a lean initiative successful. Developed by the most competitive automotive manufacturer in the world, lean manufacturing has been popularized in many western industrial companies since the early 1990s [2]. It has become a universal production method and numerous plants around the world have embraced it in order to replicate Toyota's outstanding performance. Though lean manufacturing started in the automotive industry, it was reported to be applied in other sectors as well [3-4]. Today, many organizations are enthusiastic to adopt lean manufacturing in order to improve their performance in this competitive globalized market where uncertainty is prevalent [5]. Lean manufacturing is much more than a technique; it is a way of thinking and a whole system approach that creates a culture in which everyone in the organization continuously improve operations. Lean thinking puts cost reduction—both fixed and variable at the center of all improvement efforts. It recognizes no end to the reduction of effort, time, space, cost and mistakes.

During the preliminary literature review, it has been observed that less research work is reported on role of top management in implementation lean manufacturing system in Indian context; hypothesis testing of the identified variables relevant to Indian automobile industry need to be done; and dynamics of these variables needs to be examined.

Literature Review: Variable Identification

Lean is a production practice that contained the expenditure of resources for achievement the target. In this practice the waste is completely removed throughout the process and added the value in production. Value is any action or process that a customer would be willing to pay. Lean manufacturing is a variation on the idea of efficiency based on optimizing flow; it is a present day instance of the recurring theme in human history towards increasing efficiency, decreasing waste, and using empirical methods to decide what matters, rather than uncritically accepting pre-existing ideas. At first, many confused the tools and practices with the system itself, focusing mainly on the visible aspects of lean such as Single Minute Exchange of Dies (SMED), Kanban, Process Mapping, 5S and Total Productive Maintenance [6]. The extension of the lean concept from manufacturing to other industries such as services, led to difficulties in the direct transfer of tools and practices. As a consequence of this concept stretching, lean started being described as a philosophy rather than a collection of tools, and researchers focused on underlying principles. Five lean principles which form a sequence of implementation. (1) Specify what does and does not create value from the customer's perspective; (2) identify all the steps necessary to design, order and produce the product across the whole value stream to highlight non-value-adding waste; (3) make those actions that create value flow without interruption, detours, backflows, waiting or scrap; (4) only make what is pulled by the customers just-in-time; (5) strive for perfection by continually removing successive layers of waste as they are uncovered [7].

Lean manufacturing system described a set of four rules. (1) All work is highly specified as to content, sequence, timing and output; (2) Every customer-supplier connection is direct, and there is an unambiguous yes-or-no way to send requests and receive responses; (3) The pathway for every product/service is simple and direct; (4) Improvements in accordance with the scientific method, under guidance of a teacher, at the lowest level possible [6].

Toyota production system had two distinctive features, (1) JIT – only the necessary products at

the necessary time on necessary quantity are manufactured and stock on hand is kept at a minimum (this feature also includes Jidoka-making equipment or operation stop automatically when there is a problem); (2) Respect-for-human system – workers are allowed to display their capabilities in full through active participation in running and improving their own workshops [8]. Lean production system identified seven design elements; Elimination of waste, Continuous Improvement, Multifunctional Teams, Zero Defects/JIT, Vertical Information Systems, Decentralized Responsibilities/Integrated Functions and Pull instead of Push [9]. There are five essential factors that points out achievements with lean production. These are: Managing low inventories, production pull in response to the customer, work organization into teams with multi-skilled workforce who eliminates the non added value, integrating the complete value chain into the lean process [10].

Lean Process Tools

Lean in manufacturing focuses on improving the throughput of a facility, reducing the lead time, inventory, defects, rework and process wastes and ultimately improving financial savings and customer satisfaction [11]. Lean has helped streamline operations and increase value as perceived by customers [12]. Recent research has shown that organizations have attained significant achievements due to implementing lean practices. By applying lean techniques in a manufacturing unit resulted in improved performance in terms of productivity and quality [13]. This presents the potential of improving quality while simultaneously decreasing cost in manufacturing facilities. "Process Improvement" refers to a strategy of finding solutions to eliminate the root cause of performance problems in processes that already exist in your company. Process Improvement efforts seek to fix problems by eliminating the causes of variation in the process while leaving the basic process intact. In Six Sigma terms, Process Improvement teams find the critical Xs (causes) that create the unwanted Ys (defects) produced by the process. 5S is a set of techniques, all beginning with the letter "s" [14]. They are used to improve workplace practices that facilitate visual control and lean implementation. The 5Ss are: Separate, Set to order, Shine, Standardize, Sustain. 5S is the foundation for continuous improvement, zero defects, cost reduction, and a safe work area and is a systematic way to improve the workplace, processes, and products through production line employee involvement. The 5S definitions are as follows in Table 1.

Table 1: Definitions of 5S

Term	Definition
Sort	Clearly distinguish needed items from unneeded items and eliminate the latter
Set in order	Keep needed items in the correct place to allow for easy and immediate retrieval.
Shine	Keep the work area swept and clean.
Standardize	Standardize cleanup.
Sustain	Make a habit of maintaining established procedures.

Table 2: Definitions of the DMAIC process

Term	Definition
Define	Review project charter, validate problem statement and goals, validate voice of the customer, validate financial benefits, create communication plan, select and launch team, develop project schedule, complete define gate.
Measure	Value Stream Map for deeper understanding, identify key metrics, develop operational definitions, develop data collection plan, collect baseline data, determine process capability, complete measure gate.
Analyze	Determine critical inputs, identify potential root cause, reduce list of potential root causes, prioritize root cause, complete analyze gate.
Improve	Develop potential solutions, evaluate and select best solutions, develop and implement pilot solution, develop full scale implementation plan, complete improve gate.
Control	Implement mistake proofing, implement SOP's and process controls, implement solution and ongoing process measurements, complete control gate, transition monitoring/control to process owner.

DMAIC (Define, Measure, Analyze, Improve and Control) is a structured problem-solving methodology widely used in business [15]. These phases lead a team logically from defining a problem through implementation solutions linked to underlying causes, and establishing best practices to make sure the solutions stay in place [16]. They have been proven in practice, time and again, that they can bring nearly miraculous progress to what you thought were "intractable" problems. They are the tools that can achieve breakthrough performance improvements in quality, cost, and lead time.

A review of literature suggests that the implementation of lean principles is not a onetime look at a process and through implementation, perfect results are achieved. Lean implementation is a journey that takes many years and requires a cultural change. If the principles are applied correctly, significant results can be achieved in the manufacturing process by understanding the use of value stream maps, performing time studies, utilizing spaghetti diagrams, and focusing on incremental changes to the process through the use of Kaizen events.

Lean means "manufacturing without waste." Waste is anything other than minimum amount of equipment, materials, parts, and working time that are absolutely essential to production. The lean approach is focused on systematically reducing waste (Muda) in the value stream. The waste concept includes all possible defective work/activities, not only defective products. Waste can be classified in eight categories:

- Motion: movement of people that does not add value.
- Waiting: idle time created when material, information, people or equipment is not ready.
- Correction: work that contains defects, errors, reworks mistakes or lacks something necessary.
- Over-processing: effort that adds no value from the customer's viewpoint.
- Over-production: producing more than the customer needs right now.
- Transportation: movement of product that does not add value.
- Inventory: more materials, parts or products on hand than the customer needs.
- Knowledge: people doing the work are not confident about the best way to perform tasks.

From the above literature review, we are findings variables important to implement lean manufacturing. These variables have their own perspective in implementation of lean manufacturing implementation in Indian automobile industries. From the experts view, these variables are interrelated with each other, to which are illustrated in Table 3.

Top Management Commitment

Top management support and commitment is necessary for any strategic program success [17]. Therefore, we assume that lack of top management is one of the major barrier to implementing of "Lean" concept in manufacturing system. The success of companies and managers depends on their ability to react, operate and adapt to change [25]. Consistency in management

Table 3: Variables for hypothesis testing

S. No.	Variables	References
1	Top management commitment	[7],[17], [18], [25], [26] & [27]
2	Capability and competence of sales network	[7]
3	Quality of human resources	[18],[19], [28], [29] & [30]
4	Customer involvement in quality program	[22], [23], [31] & [32]
5	Collaborative decision making	[24], [33] & [34]

commitment is emphasized as important element in effective implementation of changes in organizations [25]. The perspective of lean thinking as an integrated overall management approach is vague at the managerial level. The managers perceived Lean as a manufacturing tool for enhancing the shop floor operations. The other company shares the positive effect of implementing Lean at all areas of the organization, and emphasizes the benefits of it not only in the manufacturing, but also in the marketing department. The fourth company brings forward as the main reason for implementing lean thinking – the competitive advantage that the company would gain with it ahead of its rivals. For many managers is surprisingly difficult to implement a lean system [26].

The explanation for this paradox is that lean and quality approaches require a fundamentally different philosophy of management than the traditional mass production approach. To transform into lean organization, a company needs three types of leaders:

- Someone who is committed to the business in a long run and can be the anchor that will provide stability and continuity- an experienced worker with longer history in the company
- Someone with deep knowledge about lean techniques – lean specialist
- Someone who can be the champion/leader and fight against the organizational barriers arose as a result of the dramatic change in the organizational operations [7].

Managers on each hierarchical level of an organization have separate tasks and contributions which are complementary in a lean system. While senior leaders must practice going to the gemba (the place of work/workshop floor), lower level leaders actively teach and practice root cause problem solving. Going to the gemba is central in lean leadership, but being present in the place of work is not enough, leaders go to the place, observe the process and talk to the people [27].

Capability and Competence of Sales Network

Economic and competitiveness factors related to customer responsiveness, product quality, and cost are increasingly driving U.S. companies to implement lean production systems. Global competition is intensifying across nearly every business sector. The core of lean is founded on the concept of continuous product and process improvement and the elimination of non-value added activities. "The Value adding activities are simply only those things the customer is willing to pay for, everything else is waste, and should be eliminated, simplified, reduced, or integrated [7]".

Quality of Human Resources

Employees who are motivated and empowered are essential since people are the key element in lean manufacturing. Japanese regard people as assets [28] because they are the ones who are going to solve problems and improve processes in production. The phrase "No one knows the job better than those who do it" indicates that the person who is experienced in his/her job is most likely to have a better understanding on it. Task rotation creates cross-trained and multi-tasked employees, and this enables them to respond faster to changes in products and processes. In addition, work teams are critical throughout the implementation of lean manufacturing [18]. It is said that work teams are the heart of a lean manufacturing company [19]. To turn the employees towards participation a new way of thinking is needed. Barriers that reduce the speed of processes of change drastically have to be overcome, and motivation has to be built up [29]. Many employees report a culture shock when their organization started to implement lean processes, practices and principles [30].

Customer Involvement in Quality Programs

Relationship with customers is also crucial in lean manufacturing [31] [32]. Customers decide what to buy, and when and how they are going to purchase a product. Since value is determined by the customers, it is essential to develop a good relationship with them. Setting up good relationships with customers will enable an organization to understand and meet their needs and predict their demands accurately, as it is important to attain a perfect match between market demands and production flows [22].

Collaborative Decision Making

Team decision-making authority and authority to act corresponds to the level of team accountability [24]. This is about developing individuals through team problem-solving. The idea is to develop and engage people through their contribution to team performance. Shop floor teams, the whole site as team, and team Toyota at the outset. Lean manufacturing is developed by Taiichi Ohno at Toyota Motor Company in the 1950's as "an innovation technique based on the minds and hands philosophy of the craftsmen era, merging it with work standardization and assembly line of the Fordism system, and adding the glue of teamwork, for good measure" [33]. Seeing employees as capable and valuable for the organization is required if the managers want them actively participating in the improvement program. They will only contribute to the organizational goals if they believe that these goals are aligned with their own individual interests [34]. Individual characteristics of the employees also play an important role for the successful job enrichment. Teamwork and empowerment of the employees are identified as important by all the managers.

Methodology

A questionnaire based study had been carried out and respondents were asked to rank above variables on Likert scale of 1-5 (where 1 means "not important" and 5 means "most important". In this questionnaire, we have five variables such as Top Management Commitment; Collaborative Decision Making; Customer Involvement in Quality Programs; Quality of Human Resources & Capability and Competence of Sales Network. With the help of Mini Tab software, the statistical analysis has been carried out. During the statistical analysis, "Two sample t" test has been derived that perform the hypothesis testing. The Steps of methodology explained in the Figure 1. A pilot test was conducted to ensure the results of the questionnaire are valid and meet the objectives of this project. This is done by distributing questionnaire to lean expertise of the industries. A discussion was held with the respondents regarding the questionnaire and the feedback given by the respondents helped the researcher to edit and make changes to the questionnaire. Besides, based on the pre-test, total time spent to answer the questionnaire is ascertained. Three hundred questionnaires were sent to respondents. Out of them Eighty two questionnaires were considered for the study and Fifteen questionnaires discarded due to incompleteness (Figure 2). The responses gathered were analyzed using qualitative data analysis

techniques. Statistical means were used to illustrate the relationships between variables using the Mini Tab software. The research is done by interviewing the key persons who involve in implementing Lean Manufacturing in industries. Peer debriefing and conformability techniques were used to check the uniformity of data gathered from different sources. So the gathered data is valid. From the statistical analysis of the variables the terms Means, Standard deviation, Variance & Kurtosis values discussed in Table 4.

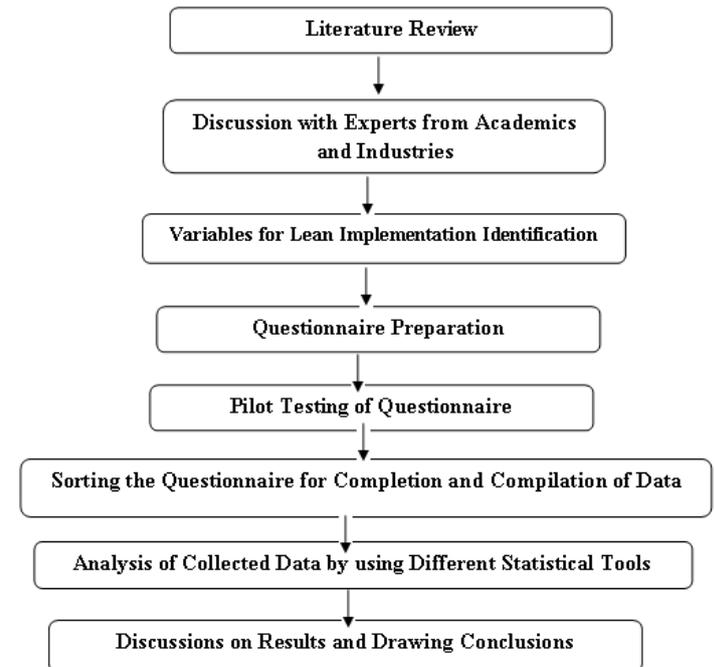


Fig. 1: Steps of methodology used in the current research

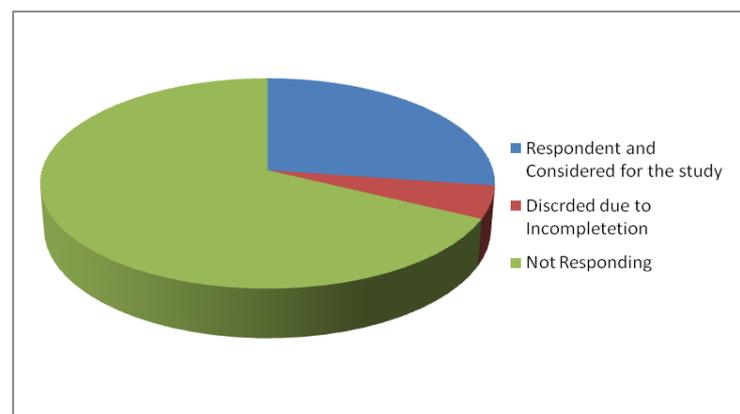


Fig. 2: Responses of questionnaire based survey carried out

Hypothesis Testing of Variables

The hypothesis testing of the variables which are important to implement lean in Indian automobile industry, we carried out the hypothesis relationship between the factors as Top management commitment, Quality of the human resources, Collaborative decision making, Customer involvement in quality program, Capability and competence of the sales network.

Table 4: Mean and variance of the variable

Variables for Lean Implementation	Mean	St. deviation	Variance	Coefficient variance	of Kurtosis
Top Management commitment	4.175	0.813	0.661	19.47	-1.4
Capability and Competence of sales network	3.425	0.5943	0.3532	17.35	0.24
Quality of human resources	3.65	0.834	0.695	22.84	-1.13
Collaborative decision making	3.625	0.667	0.446	18.41	-0.6
Customer involvement in Quality program	3.525	0.716	0.512	20.3	-0.28

Hypothesis testing between Top management commitment and Quality of human resources:

H0: There is no significant relationship between Top management commitment and Quality of human resources.

Ha: There is significant relationship between Top management commitment and Quality of human resources.

Table 5: Two-sample T-test and CI: top management commitment Vs quality of human resources

Variable	Mean	Standard deviation
Top Management Commitment	4.175	0.813
Quality of Human Resources	3.650	0.834

Difference = μ (Top Management Commitment) - μ (Quality of Human resources)

Estimate for difference: 0.525

95% CI for difference: (0.158, 0.892)

T-Test of difference = 0

(vs not =): T-Value = 2.85

P-Value = 0.006; DF = 77

Hence we reject the null hypothesis and there is significant relationship between Top management commitment and Quality of human resources.

Hypothesis testing between Top Management Commitment and Collaborative Decision Making

H0: There is no significant relationship between Top management commitment and Collaborative decision making.

Ha: There is significant relationship between Top management commitment and Collaborative decision making.

Table 6: Two-sample T-test and CI: top management commitment Vs collaborative decision making

Variable	Mean	Standard deviation
Top Management Commitment	4.175	0.813
Collaborative Decision Making	3.625	0.667

Difference = μ (Top Management commitment) - μ (Collaborative decision making)

Estimate for difference: 0.550

95% CI for difference: (0.219, 0.881)

T-Test of difference = 0

(vs not =): T-Value = 3.31

P-Value = 0.001; DF = 75

Hence we reject the null hypothesis and there is relationship between Top management commitment and collaborative decision making.

Hypothesis testing between Top management commitment and Customer Involvement in Quality Program

H0: There is no significant relationship between Top management commitment and Customer involvement in Quality program.

Ha: There is significant relationship between Top management commitment and Customer involvement in Quality program.

Table 7: Two-sample T-test and CI: top management commitment Vs customer involvement in quality program

Variable	Mean	Standard deviation
Top management commitment	4.175	0.813
Customer Involvement in Quality Program	3.525	0.716

Difference = μ (Top Management commitment) - μ (Customer Involvement in Quality)

Estimate for difference: 0.650

95% CI for difference: (0.309, 0.991)

T-Test of difference = 0

(vs not =): T-Value = 3.80

P-Value = 0.000; DF = 76

Hence we reject the null hypothesis and there is relationship between Top management commitment and Customer involvement in Quality program.

Hypothesis testing between Top Management Commitment and Capability and Competence of Sales Network

H0: There is no significant relationship between Top management commitment and Capability and Competence of sales network.

Ha: There is significant relationship between Top management commitment and Capability and Competence of sales network.

Table 8: Two-sample T-test and CI: top management commitment Vs capability of sales network

Variable	Mean	Standard Deviation
Top management commitment	4.175	0.813
Capability of Sales network	3.425	0.594

Difference = μ (Top Management commitment) - μ (Capability of sales network)

Estimate for difference: 0.750

95% CI for difference: (0.433, 1.067)

T-Test of difference = 0

(vs not =): T-Value = 4.71

P-Value = 0.000 DF = 71

Hence we reject the null hypothesis and there is relationship between Top management commitment and Capability and Competence of sales network.

Regression Analysis

*Quality of human resources is highly correlated with other X variables

*Quality of human resources has been removed from the equation.

*Customer Involvement in Quality is highly correlated with other X variables

*Customer Involvement in Quality has been removed from the equation.

Table 9: Top management commitment regression analysis results

Predictor	Coefficient	SE Coefficient	T	P
Constant	1.5369	0.4465	3.44	0.001
Capability of Sales Network	0.2890	.1055	02.74	0.008
Collaborative Decision Making	0.4387	0.1316	3.33	0.001

S = 0.674523; R-Sq = 32.0%; R-Sq (adj) = 30.3%

The regression equation is:

Top Management commitment = 1.54 + 0.289 Capability of Sales Network + 0.439 Collaborative Decision Making.

This regression shows that the Top management is highly correlated with quality of human resources and customer involvement in quality program. The variables (Capability of Sales Network & Collaborative Decision Making) shall be related with Top management commitment.

Results & Discussions

Lean Manufacturing System has been identified as an approach for improving performance of the processes and products. Five factors to implement lean manufacturing in Indian automobile industry have been taken under the hypothesis test. Mini Tab has been used for the finding the statistical analysis among variables like Top management commitment, Customer involvement in quality program, Collaborative decision making, Quality of human resources & Capability and competence of the sales network. From module 3.1.1 to 3.1.4, the variables taken for 2-sample-t test, which clarified the p values for each hypothetical test for individual variables (Quality of human resources, customer involvement in quality program Collaborative decision making & Capability and competence of the sales network) with the variable (Top management commitment). From 3.2, the Regression analysis result summaries for finding the strong relationship with the respective variables. In this research, the variable (Top management commitment) has been strongly co-relate with the other variables (Customer involvement in quality program, Quality of human resources, Collaborative decision making, Capability & competence of sales network) under 2-Sample-t-test analysis. From the hypothesis testing, we findings the role of variables in lean implementation, Top management commitment is related to the other variables. It shows that the initiative shall be taken from the top management, if the top management not contributing in lean, working of other factors not effective as per their capability. From the regression analysis, the variable (Top management commitment) has highly correlated with the Quality of human resources & customer involvement in quality program. Collaborative decision making & Capability and competence of the sales network shall drawn relation with Top management commitment from the equation finding from the regression analysis. The entire variable has p value less than 0.05 that shows their confidence interval is more than 95%. The p

value from the 2-sample-t and Regression proved the hypothetical test for the variables for implementation of lean manufacturing in Indian automobile industry.

Conclusions

Customer involvement in quality program, Quality of human resources, Collaborative decision making, Capability & competence of sales network have been proved the hypothetical test with Top management commitment in lean manufacturing system implementation in Indian automobile industries. Literature review and discussions with experts have helped to findings the correlation among factors applicable to lean manufacturing system implementation based upon their importance. Top management is the

initiative variables which has leadership relation with the other variables to implement lean in automobile industries. Literature review and subsequent discussions with experts have helped to sort the factor relevant to lean manufacturing system implementation based upon their importance. There is relationship between the top management commitment and Capability and competence of sales network that was shown by the p-value which is less than 0.001. We can say that if we want to a waste free and value added manufacturing environment then these variables (Top management commitment, Customer involvement in quality program, Quality of human resources, Collaborative decision making, Capability & competence of sales network) are very useful for in implementing lean in Indian automobile industries.

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