A STRUCTURAL EQUATION MODEL ASSESSMENT OF CRITICAL SUCCESS FACTORS (CSF), LEAN PERFORMANCE INDICATORS (PI) AND BARRIERS FOR AUTOMOTIVE INDUSTRIES

Nareshkumar D. Chauhan
Dr. Pranav H. Darji
Dr. M. N. Qureshi
Dr. T.N. Desai

Abstract

Lean Manufacturing is a systematic methodology that identifies and eliminates all types of waste or non-value-added activities; not only in production or manufacturing operations, but in the service industry as well. The main purpose of this study is to identify the adoption of the lean manufacturing along with Critical Success Factors (CSF), Performance Indicators (PI) and barriers. This study helps to find the co-relation of each parameter in Lean Manufacturing (LM) practices. A survey is conducted within the automobile parts manufacturing industries of Gujarat. The present study illustrates the reliability of the data obtained from the survey and analysis of the available data in terms of Critical Success Factors (CSF), Performance Indicators (PI) and barriers within industries. The selection of the strategies are done on the basis of the survey and reviews from the industries who have gained more than 15% of benefits after implementation of Lean manufacturing. The best five strategies of Critical Success Factors (CSF), Performance Indicators (PI) and barriers have been selected for which Lean manufacturing offers waste reducing strategies like elimination and identification of the waste and also enhancing their productivity and competitiveness.

Keywords: Lean manufacturing, Structural Equation Modelling (SEM), Critical Success Factors (CSF), Performance Indicators (PI), barriers, automotive industries

1. INTRODUCTION

A globalization and industrialization forced manufacturing company to identify and explore the opportunities for reducing their cost without compromising the operational performance. As a result of this, Lean manufacturing gets attention not only from the industrialists but also from researchers as well as academicians. Lean manufacturing is a methodology that comprises the simultaneous application of many techniques and tools. Lean manufacturing is also defining as a philosophy that are having strategic principles, such as waste reduction and continuous improvement.

In book, “The Machine that changed the world” the result statistically shows the core business performance measures [16]. Toyota production methods are far better than the production in the American car industries. Production system of Toyota is spread through many regions of the world under the label of lean. The lean manufacturing implementation performances are still being questioned, though techniques, methods and mind set for LM is well documented. In this paper, relationship and dependency between the Performance Indicators (PI), Critical Success Factors (CSF) and barriers have been developed through Structural Equation Modelling (SEM). This paper proposes to empirically test the relationships among the Performance Indicators (PI), Critical Success Factors (CSF) and barriers in the automotive industries in Gujarat. Although the Automotive industries have been developed in Gujarat since last one decade, they comprise major percentage of the industries in Gujarat state. So this empirical study provides useful insights to other industrial segments also. This study helps to guide the research direction in other developing countries also having similar situations and circumstances. This finding helps to conceptualize the empirical concept of Lean manufacturing and implement in the real operational level.

Lean manufacturing is an enough for the success of the industries. Its successful implementation is also an important consideration for the authors. Critical success factors important since it drawing the strategies for success full implementation of lean manufacturing. Performance indicator are the measures of the lean manufacturing implementation. There are several authors who have mentioned more the 30 strategies for each critical success factors, performance indicator and barriers in lean manufacturing implementation.

The rest of the paper is arranged as follows. Section – I ipresents the introduction to Structural Equation Modelling (SEM). Section-III presents the research framework and defines the multidimensional constructs of Performance Indicators (PI), Critical Success Factors (CSF) and barriers. The research is also supported with the hypothesis testing. Section – IV, encompasses the research methodology and also presents the main sources of data. The obtained results are then explained and analyzed in Section-V. The detailed discussion of result and implication for the result are also covered in this section. Section-VI discusses the conclusion of the ongoing research.

2. STRUCTURAL EQUATION MODELLING (SEM)

The definition of Structural Equation Modelling (SEM) is difficult to find but proposes that, “Structural Equation Modelling (SEM) can perhaps best be defined as a class of methodologies that seeks to represent hypotheses about the means, variances and covariance of observed data in terms of a smaller number of 'structural' parameters defined by a hypothesized underlying model” [1]. The main objective of the Structural Equation Modelling (SEM) is to compare the theoretical and empirical data with the extracted data model. This is followed by the fitting of the model and data in terms of the statistics which assess the matching of model and data. If it is fit to acceptable limit, then relationship and dependencies between various latent variables and observed variables have been supported. Although under specific conditions, Structural Equation Modelling (SEM) can formulate causal relationships between two constructs, a dependency does not mean a well-
fitting structural equation modeling. Several authors have used the SEM techniques for extracting the relationship between the finance, innovative performance, environmental factor and lean manufacturing implementation. Number of software are available for the Structural Equation Modelling (SEM), but in this research, SPSS AMOS software has been used for analysis. There are several other techniques are available for the same objectives such as multi regression analysis, neural network modeling, analytical hierarchy analysis, genetic algorithm modeling, multi regression analysis and any other. But SEM is best suited algorithm for this study because of SEM allows multiple measure to associate with single latent construct.

3. RESEARCH METHODOLOGY
The framework which forms the basis of this research is presented in Figure 1, and which is identical to one used by Li, Ragu Nathan & Rao (2006). The framework proposed that the Critical Success Factors (CSF) and Performance Indicators (PI) have greater impact on the Lean manufacturing implementation. The implementation barriers also have an impact on the above mention two factors (CSF and PI).

![Figure 1 Hypothesis Development](image)

3.1 Hypothesis Development
The research framework used in the study proposes that the implementation of Lean manufacturing practices has a direct impact on the business performance of an organization. Earlier it has been found that good strategy of business was anti-ethical for pursuing environmental goals [4]. As a top management view, achieving business performance without overcoming environmental barriers is not possible. Some of the authors challenged this and argued that designing of the environmental standards can trigger the Critical Success Factors (CSF) which can improve the productivity, which ultimately increases the competitive standards [5]. Some of the prior work in this area suggests that productivity must be ultimately profitable if it is having high environmental performance [6]. Some activities regarding environment reduced emissions and waste prevention. These environmental activities are associates of lean manufacturing with greater financial performance [7]. However, it should not be taken as a foregone conclusion that LM practices will have a positive impact on business performance [8]. Whole literature seems to support a ‘win-win’ hypothesis [9].

Hypothesis-1: The Performance Indicators (PI) in implementation of LM will be positively associated with Critical Success Factors (CSF).

Hypothesis-2: The barriers in implementation of LM will be negatively associated with Performance Indicators (PI).

Hypothesis-3: The barriers in implementation of LM will be negatively associated with Critical Success Factors (CSF).

4. METHODS
4.1 Survey Instrument and Data Collection: A survey based method has been adopted for the empirical result. Study examines around 134 companies. These studies consist of questions divided in 5 different segments.

4.2 Measures: The questionnaire for survey has been designed and prepared from the literature review to obtain the effective response and detailed status of the lean implementation in industries. The responses of sections I and II contain industrial demographic details as well as lean status of the industry. Responses of sections III, IV and V contain five points scale range, where the importance of particular factors increases in ascending order. Around 18% of response rate is adequate for research in manufacturing industries. [11]

4.3 Sample and Respondent Profile: In this survey study 134 data samples were collected from various automotive parts manufacturing industries. Among these respondents data 2.2% were OEM, 41% were TIER 1 and remaining 56.8% were TIER 2 or higher. This indicates that responses obtained where from all category of manufacturing industries. The Performance Indicators (PI) are sub categorized in five major parameters namely Finance, Customers, Process, People and Future. The remaining two factors (CSF and Barriers) are considered as main parameter so on. All factors are consisting of five best strategies related to its own parameter. The selection of the best five strategies have been done on the basis of the rating given by the industries in the survey. These strategies are given by the companies through the survey, whose benefits are more than 15% after lean manufacturing implementation. Below table shows the five strategies of all three factors.

<table>
<thead>
<tr>
<th>Critical Success Factors (CSF)</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrange education and awareness program</td>
<td>Hero Syndrome</td>
</tr>
<tr>
<td>Development of Clear Strategies for Lean Program</td>
<td>Culture and managerial impacts</td>
</tr>
<tr>
<td>Plan shared early and communicate fully</td>
<td>Impression of top leadership support</td>
</tr>
<tr>
<td>Establish the common goals and joint matrices</td>
<td>Reacting without careful consideration of word and action</td>
</tr>
<tr>
<td>Utilize the change process and hold the firm</td>
<td>Change without theoretical basis</td>
</tr>
</tbody>
</table>

Table 1 Selected strategies for SEM model

4.4 Structural Model Testing: The research framework used in the study proposes that the implementation of Lean manufacturing practices has a direct impact on the business performance of an organization. Earlier it has been found that good strategy of business was anti-ethical for pursuing environmental goals [4]. As a top management view, achieving business performance without overcoming environmental barriers is not possible. Some of the authors challenged this and argued that designing of the environmental standards can trigger the Critical Success Factors (CSF) which can improve the productivity, which ultimately increases the competitive standards [5]. Some of the prior work in this area suggests that productivity must be ultimately profitable if it is having high environmental performance [6]. Some activities regarding environment reduced emissions and waste prevention. These environmental activities are associates of lean manufacturing with greater financial performance [7]. However, it should not be taken as a foregone conclusion that LM practices will have a positive impact on business performance [8]. Whole literature seems to support a ‘win-win’ hypothesis [9].

Hypothesis-1: The Performance Indicators (PI) in implementation of LM will be positively associated with Critical Success Factors (CSF).

Hypothesis-2: The barriers in implementation of LM will be negatively associated with Performance Indicators (PI).

Hypothesis-3: The barriers in implementation of LM will be negatively associated with Critical Success Factors (CSF).

4. METHODS
4.1 Survey Instrument and Data Collection: A survey based method has been adopted for the empirical result. Study examines around 134 companies. These studies consist of questions divided in 5 different segments.

4.2 Measures: The questionnaire for survey has been designed and prepared from the literature review to obtain the effective response and detailed status of the lean implementation in industries. The responses of sections I and II contain industrial demographic details as well as lean status of the industry. Responses of sections III, IV and V contain five points scale range, where the importance of particular factors increases in ascending order. Around 18% of response rate is adequate for research in manufacturing industries. [11]

4.3 Sample and Respondent Profile: In this survey study 134 data samples were collected from various automotive parts manufacturing industries. Among these respondents data 2.2% were OEM, 41% were TIER 1 and remaining 56.8% were TIER 2 or higher. This indicates that responses obtained where from all category of manufacturing industries. The Performance Indicators (PI) are sub categorized in five major parameters namely Finance, Customers, Process, People and Future. The remaining two factors (CSF and Barriers) are considered as main parameters only. All factors are consisting of five best strategies related to its own parameter. The selection of the best five strategies have been done on the basis of the rating given by the industries in the survey. These strategies are given by the companies through the survey, whose benefits are more than 15% after lean manufacturing implementation. Below table shows the five strategies of all three factors.

Table 1 Selected strategies for SEM model

<table>
<thead>
<tr>
<th>Critical Success Factors (CSF)</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrange education and awareness program</td>
<td>Hero Syndrome</td>
</tr>
<tr>
<td>Development of Clear Strategies for lean Program</td>
<td>Culture and managerial impacts</td>
</tr>
<tr>
<td>Plan shared early and communicate fully</td>
<td>Impression of top leadership support</td>
</tr>
<tr>
<td>Establish the common goals and joint matrices</td>
<td>Reacting without careful consideration of word and action</td>
</tr>
<tr>
<td>Utilize the change process and hold the firm</td>
<td>Change without theoretical basis</td>
</tr>
</tbody>
</table>

4.4 Structural Model Testing: The research framework used in the study proposes that the implementation of Lean manufacturing practices has a direct impact on the business performance of an organization. Earlier it has been found that good strategy of business was anti-ethical for pursuing environmental goals [4]. As a top management view, achieving business performance without overcoming environmental barriers is not possible. Some of the authors challenged this and argued that designing of the environmental standards can trigger the Critical Success Factors (CSF) which can improve the productivity, which ultimately increases the competitive standards [5]. Some of the prior work in this area suggests that productivity must be ultimately profitable if it is having high environmental performance [6]. Some activities regarding environment reduced emissions and waste prevention. These environmental activities are associates of lean manufacturing with greater financial performance [7]. However, it should not be taken as a foregone conclusion that LM practices will have a positive impact on business performance [8]. Whole literature seems to support a ‘win-win’ hypothesis [9].

Hypothesis-1: The Performance Indicators (PI) in implementation of LM will be positively associated with Critical Success Factors (CSF).

Hypothesis-2: The barriers in implementation of LM will be negatively associated with Performance Indicators (PI).

Hypothesis-3: The barriers in implementation of LM will be negatively associated with Critical Success Factors (CSF).

4. METHODS
4.1 Survey Instrument and Data Collection: A survey based method has been adopted for the empirical result. Study examines around 134 companies. These studies consist of questions divided in 5 different segments.

4.2 Measures: The questionnaire for survey has been designed and prepared from the literature review to obtain the effective response and detailed status of the lean implementation in industries. The responses of sections I and II contain industrial demographic details as well as lean status of the industry. Responses of sections III, IV and V contain five points scale range, where the importance of particular factors increases in ascending order. Around 18% of response rate is adequate for research in manufacturing industries. [11]

4.3 Sample and Respondent Profile: In this survey study 134 data samples were collected from various automotive parts manufacturing industries. Among these respondents data 2.2% were OEM, 41% were TIER 1 and remaining 56.8% were TIER 2 or higher. This indicates that responses obtained where from all category of manufacturing industries. The Performance Indicators (PI) are sub categorized in five major parameters namely Finance, Customers, Process, People and Future. The remaining two factors (CSF and Barriers) are considered as main parameters only. All factors are consisting of five best strategies related to its own parameter. The selection of the best five strategies have been done on the basis of the rating given by the industries in the survey. These strategies are given by the companies through the survey, whose benefits are more than 15% after lean manufacturing implementation. Below table shows the five strategies of all three factors.

Table 1 Selected strategies for SEM model

<table>
<thead>
<tr>
<th>Critical Success Factors (CSF)</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrange education and awareness program</td>
<td>Hero Syndrome</td>
</tr>
<tr>
<td>Development of Clear Strategies for lean Program</td>
<td>Culture and managerial impacts</td>
</tr>
<tr>
<td>Plan shared early and communicate fully</td>
<td>Impression of top leadership support</td>
</tr>
<tr>
<td>Establish the common goals and joint matrices</td>
<td>Reacting without careful consideration of word and action</td>
</tr>
<tr>
<td>Utilize the change process and hold the firm</td>
<td>Change without theoretical basis</td>
</tr>
</tbody>
</table>
5. RESULTS
The conceptual model shown was tested using the Partial Least Squares Structural Equation Modelling (PLS-SEM) technique [12]. SPSS AMOS have been used for the analysis of the available data which is collected by the survey. Cronbach's alpha has been calculated for testing the reliability of the survey data. Cronbach's alpha need to be above 0.7 for the reliable data. Here data is reliable enough for further analysis of the available data and the analysis which is done are taken as a feasible result if all of three hypothesis would get satisfied.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barriers</td>
<td>0.961</td>
</tr>
<tr>
<td>Critical Success Factors (CSF)</td>
<td>0.935</td>
</tr>
<tr>
<td>Performance Indicators (PI)</td>
<td>0.931</td>
</tr>
</tbody>
</table>

The convergent validity shows the consistency in measuring the construct. There are two indicators which helps to find the construct validity viz. Average Variance Extracted (AVE) and Composite Reliability (CR).

Higher than 0.5 for AVE and 0.7 for CR is reliable for the convergent validity. While discriminant validity is related to the measurement of its own construct, relation with its own construct is measured with the discriminant validity.

Below mentioned Structural Equation Model (SEM) shows the convergent validity and discriminant validity which indicates lean manufacturing implementation practices for the Performance Indicators (PI), Critical Success Factors (CSF) and Barriers. Amongst all of them, the best five strategies have been selected from the data collected for further analysis.

6. CONCLUSION
The study illustrates that the lean manufacturing practices are greatly influenced by the three main factors which are Barriers, Critical Success Factors (CSF) and Performance Indicators (PI). Table 2 illustrates the statistical co-efficient of reliability of the parameter i.e. Cronbach's Alpha for each parameter. Barriers, Critical Success Factors (CSF) and Performance Indicators (PI). This table also shows the support of each hypothesis. From the table no. 3 it has been concluded that all hypothesis satisfied successfully all three parameters are much dependent on each other. The co-relation of the PI and CSM as well as barriers are equal and it is 0.30 while co relation of the barriers and CSM are higher as compared to other parameter and which is 0.38.

The survey was done for the three most critical parameters for scrutinizing lean implementation. They were Barriers, CSF and PI. These three main factors were sub categorized further. Barriers were subcategorized into 25 parameters, CSF were subcategorized into 30 parameters and PI were divided into 5 sub factors which included 32 parameters. The best five parameters amongst all these three factors were found to be the best strategies through SPSS data analysis and a SEM was developed on this basis. The SEM is shown in figure no. 2 which indicates the co-relation of these parameters.

It has been observed that Performance Indicators (PI) are similarly affected by Critical Success Factors (CSF) and barriers in lean manufacturing implementation. Barriers in implementation of lean manufacturing are more affected by Critical Success Factors (CSF) rather than Performance
Indicators (PI). The key contribution of this study is Performance indicator and barriers are influence critical success factors. This study does not give the exact mechanism to follow, but provides the guidelines to survive the business in the fluctuating economy.

Table 3 Hypothesis and its support

<table>
<thead>
<tr>
<th>Path</th>
<th>Coefficient</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: PI → CSF</td>
<td>0.30</td>
<td>Yes</td>
</tr>
<tr>
<td>H2: PI → Barriers</td>
<td>0.30</td>
<td>Yes</td>
</tr>
<tr>
<td>H3: Barriers → CSF</td>
<td>0.38</td>
<td>Yes</td>
</tr>
</tbody>
</table>

7. REFERENCES


AUTHORS

Nareshkumar D. Chauhan, Research Scholar, C.U. Shah University
Email: ndc5275@gmail.com

Dr. Pranav H. Darji, Professor & Head, Faculty of Technology, C.U. Shah University
Email: pranav_darji@rediffmail.com

Dr. M. N. Qureshi, Associate Professor, College of Engineering, King Khalid University, Abha
Email: mrnoor@kku.edu.sa

Dr. T.N. Desai, Associate Professor Mechanical Engineering SVNIT, Surat
Email: tushardesaisvnit@gmail.com

DOI: 10.26488/IEJ.6.10.5

ISSN: 2581-4915