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Survey on Lean Manufacturing Practices in Coimbatore Pump Industries

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Abstract— **The purpose of this paper is to assess the levelness of lean practices and principles that contribute to adoption of lean in pump industries in Coimbatore, Tamil Nadu and empirically test the results by framing a Structural equation model in Visual PLS. This research approach follows a theoretical model by linking the important lean metrics that contribute to lean adoption through a questionnaire survey and assess their reliability and relationship of the responses on an ordinal scale with respect to the given constructed variables through convergent validity analysis in Visual PLS software. The approach follows a Structural equation modeling technique to empirically test the theoretical model by determining the relationship of the various responses of the respondents and the constructed variable to identify those prime lean metrics among the many practices that exist in the organization. This research is concerned only to pump industries. Further this research could be conducted in other manufacturing sectors that include machine tool, automotive, electrical and electronics and others of its kind.**

Keywords—Lean manufacturing, structural equation modelling, Smart pls.

I. INTRODUCTION

Lean Manufacturing system is considered as the fine management tool which helps the Manufacturing Firms' to enhance their competitiveness and efficiency, Major manufacturing firms are facing huge problems in resource wastage, customer dissatisfaction, environmental pollution etc. which has forced every manufacturing firms to adopt the lean technique in required forms. The main aim of lean manufacturing system is to provide the smooth flow of process inside the organization along with the minimal level of wastage and delivering high quality of finished products for the customer demand. It is designed for the high response for the production system by reducing human effort in the organization. The major lean manufacturing tools that are employed are 5s, single minute Exchange of Die, Value Stream Mapping etc. The implementation of lean manufacturing inside the manufacturing firm is a challenge that needs enhanced understanding of lean philosophy, concept and technique. All manufacturing industry must consider lean as a serious factor and spent some effort on lean manufacturing to survive in the competitive environment. Since many researchers in around the industrial sectors recommend the lean as one of the capable and effective system for turning the organization in better condition. From the emerging technology and increase in customer demand the manufacturing industries has started researching in latest technology that add values to their products. The pump manufacturing industries is considered as one of the major industrial sectors in the manufacturing firm. Over 20% of the population of the manufacturing industries in India are pump industry with the annual CAGR value of 10% with highest net value additions in manufacturing industry. Indian pump manufacturing industries usually produces 4.5 million pumps every year. The 70% of Indian pump manufacturing contains the us $ 15 trillion GDP projected for 2030 to support the urban infrastructure, with the pump export of 100 countries. Based on the report Coimbatore is the highest pump manufacturing region in india following Belgam, Batla & Jalandhar, Kolhapur etc. the main objective of the research is to identify the lean adoption inside the pump manufacturing industries in and around Coimbatore because many are not aware of the latest principles and techniques other than their positive impact on the business. In this research the critical factors for lean technique inside the pump manufacturing industry is statistically obtained with some of the tools such as convergent variance, demographic analysis, structural equation modelling and validation. The major

software play in this research survey are smart PLS and SPSS that leads to the identification of level of lean inside the organization, major rivals for lean adoption, major lean tools employed inside the industry is resulted. From the following technique it is better to understand the ways of enhancing the productivity, developing customer supplier relation, stand crucial in the competitive market etc. the research principle includes the literature survey, hypothetical question preparation with survey. It is to agree that the following research intends to determine the lean manufacturing factors contribution for the industrial growth and their strategies for latest techniques to be adopted inside the industry for the benefits of the manufacturing firms.

II. REVIEW OF LITERATURE

Picking a suitable research system of methods may leads to achieve the required objective of the study. The system of methods is classified into four parts that leads to the proper identification and understanding of the research questionnaire. The first section comprises the literature review, the second section consists of the survey questions by literature review, following it be the major lean tools related to the manufacturing firm, and finally a pilot survey is carried out for preparing final questionnaire. Peoples from the industry and Professors from the lean manufacturing courses were consulted for developing the questionnaire. Based on their knowledge and experiences the research questionnaire were altered and modified that suits best to this research. The questionnaire consisted of two sections

Module I

1. Demographic information of the respondent and his organization

Module II

2. Lean negotiations
3. Lean adoption status
4. Various lean tools used

The final questionnaire consisted of 3 major criterion and 11 sub-criteria. Each criterion in the questionnaire was referred on a five point Likert Scale (Joseph A.Gliem 2003), where, 1 =strongly disagree, 2 =disagree, 3 =average, 4 =agree and 5 =strongly agree. Likert Scale is a psychometric response scale primarily used to obtain participant's preferences or degree of agreement with a statement or set of statements. Respondents are made to select their level of values with a given statement. The third part adopted a case study approach centering on hypothesis formulation, sampling procedure and data processing procedures. This part assisted the research for which portion of population the test analysis has to be carried out based on research questions by experts and hypothesis formulation.

(Tenenhaus 2008) states that PLS modelling is the component based structural equation model. The PLS is classified into two sub models - measurement model and structural model. The relationship between the observed model and the latent model is represented in the measurement model. The relationship between the latent variables are represented in the structural model (Fornell and Bookstein 1982). The structured equation modelling was conducted through smart PLS software. Armin Monecke & Friedrich LeischIt (2012) in their paper that contributes to PLS path modeling; the latent variable (LV) scores are found as exact linear combinations of their associated manifest variables (MVs). Based on that dependence of the researcher's objectives and optimistic view of data to theory the PLS path modeling is more pertinent. The basic descriptive values and their central tendency measures are used to arrive the conclusion of the data summary (Peter M.C Harrison, 2013). A questionnaire was administered that was personally adopted from earlier studies, specifically from the works of Brah and Lim (2006), Demirbag, Tatoglu, Tekinkus, and Zaim (2006) it was modified where necessary from this considerations the determined questions were modified based on the guidance by the experts in the same field. (Oyedolapo Ekundayo Ogunbiyi, 2017) identifies the Cronbach's alpha determines the internal consistency or average correlation of items in a survey instrument to gauge its reliability. Statistical Package for the Social Sciences (SPSS) software helps in determining the reliability of the responses and also helps in determining the relationships between the observed and constructed variables through regression analysis. These methods were made to obtain accurate/precise information and data to help in determining the most practiced lean manufacturing tool among the many lean tools practiced in the organization. The AVE (Average Variance Extracted) must be greater than the 0.5, and the value which are lies about 2.00 in t-static values are considered as the significance values and others remain insignificance are to considered as the convergent and uni dimensionality values. The Crobbach alpha value should be above 0.7 that must be a healthy value, below are to be rejected. Cronbach alpha was used which was done using SPSS. Uma Sekaran (2010), describes the stability of the requirement. With the value ranges from 0 to 1.

III. RESEARCH METHODOLOGY

A. OBJECTIVES OF THE RESEARCH

- To analyze the status of lean implementation in pump manufacturing industry
- To identify various lean tools adopted in industry
- To identify the major benefits from the lean

B. VALIDATION OF QUESTIONNAIRE

This system is one of the classified method of preparing the questionnaire that focuses the researchers' requirement over the research. That includes the question validation. The questionnaire development should be depends on the lean adoption factor. The questionnaire consists of the questions on

the various aspect of lean adoption inside the pump manufacturing industry. That is divided into Content validity, construct validity and criterion validity. The most suitable method that we follow in this research is content validity combined with the construct validity. This research questions are based on the underlying constructs that are to be measured. The question's core content validation is based on the cronbach's alpha method. The score of the question must be lies in the score of 0.7 for the right system of measurement below which are to be neglected. This test can be performed in the smart PLS software. The experts and senior executives of the industries joined for discussions that are carried over for the achievement of the construct validity that provides the measurement scale for the variances. The accepted questionnaire must follow the requirement of the research carried out and must not deviate from the research objective. The unidimensionality of the questions were examined, that is essential to purify the instruments using for the measurement that does not gets correlate to the constructs. The reliability of the construct measures for accuracy repeats in same phenomenon without variations by the Cronbach's alpha method. Then the scores of the variables of each sub construct are used and they are reduced to one variable. The PLS method is a non-parametric method that do not consider any assumption that deals only with the accurate results.

C. RESEARCH FRAMEWORK

The research framework describes the research objectives and their relationship between the developed constructs for the research. It is always better to have a supportive framework of research along with the hypothesis for testing. Which is important to predict the final outcome of the research and area for future development.

D. DATA COLLECTION

The data collection is based on the sample size, a rule of thumb (Nor 2005) it explains the number variables to 10 times more than available variance from the Structural Equation Modelling. The sampling method is carried out based on the Expert sampling method and the simple random sampling method. Which the probability of choosing is based on the subset of the each members in a statistical population of each member in a simple random sample. The target lies over the peoples from the administrative, executive and supervisory levels. Thoroughly the target people for the research response are contacted for the questionnaire response by providing the proper attention and explanation over the purpose of the research and their relevance to their industry. A face to face interview, telephone call or e-mail communication is carried out over the respondents for collecting the data and providing them clear and absolute queries in the questionnaire and research carried out. The target respondents must have a better knowledge about the lean concept and its techniques.

E. INSTRUMENTATION OF HYPOTHESIS

The formation of hypothesis is the key sector for the identification of the research objective. Lean adoption is the major hypothesis for the research carried. Other sub hypothesis get depends on the identification of the major objective or hypothesis. That provides the SEM (Structural Equation Modelling) Model for the research. Each developed hypothesis is considered as the Latent variables that gets depends on the number of the Manifest variables.

F. PILOT STUDY

The initial pilot study was carried in some industries and tested. From this study there is a need for modifications to balance between the lean measurement levels that intends to measure the adoption of lean inside the industry. It delivers the major problems and metrics that are available inside the industry that follows the development and modifications in the questions developed for the industry. The major outcome of the pilot study is to confirm the instrument reliability and respondents reactions for the questions that they feel that questions are simple to understand and relevant to their field. The result from this analysis is calculated to indicate that the internal consistency lies over the major objective for the research. It concludes with proper score of Cronbach alpha of 0.7 and above it is in good reliability and can be continued for the further research.

IV. ANALYSIS AND RESULTS

A. DEMOGRAPHIC VALUE

The research consists of the small measurement scale that implies on the demographic level of the respondents is identified based on their designation, Experience and number of employees employed inside the industry.

Demographic level of respondents

Table.1 Demographic table for Designation

Designation	**Number**	**Percentage**
Engineer	6	50.00
Manager	5	41.66
Vice- President	1	08.33
TOTAL	12	100

Table.2 Demographic table for experience

Experience (years)	**Number**	**Percentage**
05 – 10	8	66.70

11 – 20	2	16.66
21 – 30	2	16.66
TOTAL	12	100

Table.3 Demographic table for number of employees

No. of employees	**Number**	**Percentage**
< 50	4	33.33
50 – 100	4	33.33
100–200	4	33.33
TOTAL	12	100

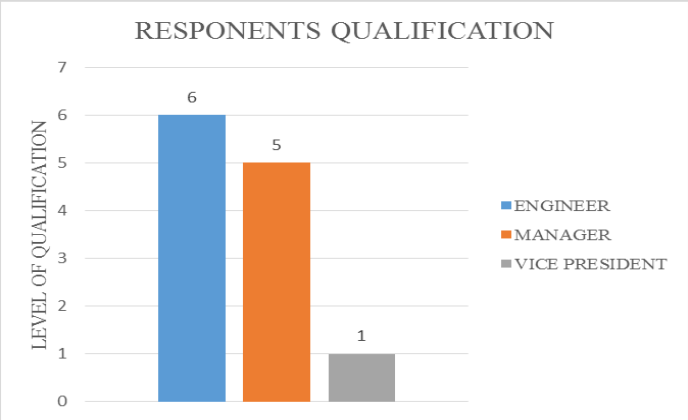

Fig. 1 Respondents qualification

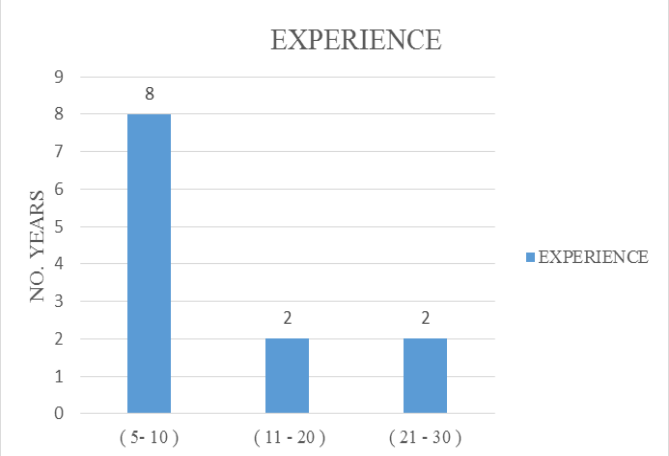

Fig.2 Respondents Experience

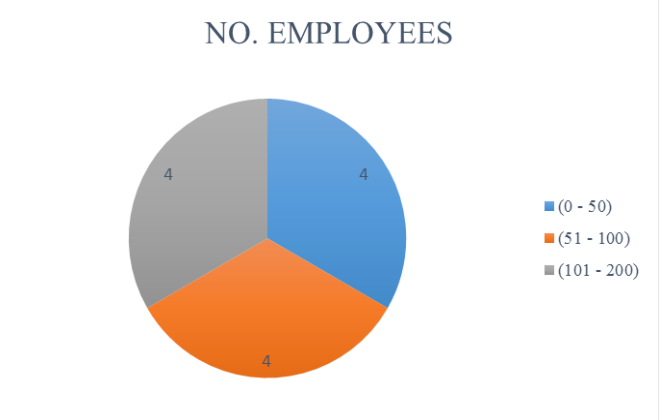

Fig.3 Number of employees in industry

B. RELIABLITY OF CONSTRUCTS

Reliability analysis was conducted for each of the 11 sub-criteria separately. All the results obtained proved that survey instrument has very good internal consistency i.e.≥0.70 and hence it is reliable. From the data the every latent variable score is above 0.7 it tends to good level of questionnaire is developed.

Table.4 Reliability of constructs

S.NO	CRITERIA	CRONBACH ALPHA
1	Lean Startup	0.939
2	Lean Tools	0.921
3	Lean Benefits	0.918
4	Lean Status	1.000

C. CONVERGENT VARIANCE

It helps in predicting the population in about the distribution of the variances employed for this research. The value of average value extracted is above 0.5 it is accepted for the research.

Table.5 Convergent variances

S.NO	CONSTRUCT	C.RELIABLITY	AVE
1	Lean Startup	0.938	0.719
2	Lean Tools	0.921	0.703
3	Lean Benefits	0.918	0.793
4	Lean Status	1.000	1.000

Headings, or heads, are organizational devices that guide Figures and Tables

D. STRUCTURAL BOOTSTRAP MODEL

Table.6 Bootstrap Model

S.NO	ESTIMATE	MEAN	S.D	T-STC	RESULT
1	Lean startup→ Lean Status	0.138	0.608	0.117	Insignificant
2	Lean tools→ Lean Status	0.572	0.513	0.958	Insignificant
3	Lean Benefits→ Lean Status	0.271	0.398	2.971	Significant

From the following results, it is found that the T-Static value for lean startup and lean tools towards the lean status lies to be lesser than 2, which states that the level of lean is low and should be improved. The value of the t- static is above 2. That denotes the level is up to the standard.

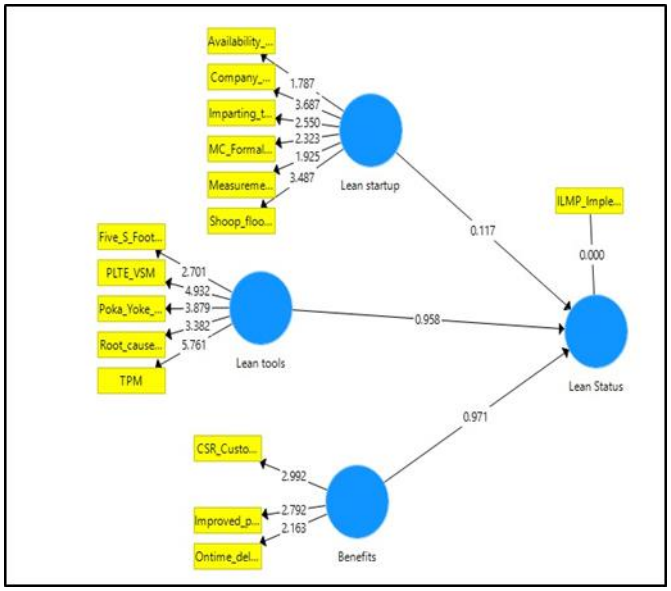

Fig. 4 PLS Bootstrap SEM Model

V. *CONCLUSION*

Lean implementation inside the organization is the future of the industrial growth. Future industries completely depends on the lean manufacturing for their development and beneficiary activities. In this project the industry should try to concentrate on their lean startup activities for adopting the lean based manufacturing system in it, the industries must also concentrate on their usage of lean tools for their industry, based on the results, many pump industries fails to use appropriate lean tools inside their industry the lean tools that are suitable for the pump industry must be properly identified and established inside the industry. Other variables such that the lean benefits are about to the standard value, that area can be concentrated least.

Hence, the future scope of the research lies with initiating major tools for the study such that statistical Package for Social Sciences (SPSS) for the development of the regression test, for analyzing the descriptive analysis, Anova test are used. These tests are conducted for the further more accurate solutions.

APPENDIX

A. ABBREVATION

Table.7 Appendix

S.D	Standard deviation
C.RELIABLITY	Composite reliability
AVE	Average variance extracted
SEM	Structural Equation modelling
SPSS	Statistical package for social science
LV	Latent variable
MV	Manifest variable
PLS	Partial least squares
CAGR	Compound annual growth rate
GDP	Gross domestic product

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