Analyzing Barriers of Lean Manufacturing Adoption in Indian SMEs Using an Integrated Approach of Grey Decision Making Trial and Evaluation Laboratory (DEMATEL)

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***Abstract*-In emerging countries such as India, whose economy position in the world is 3rd in terms of purchasing power parity, statistical data shows that manufacturing sector in 2014-2015 only contributes 17.18% of total GDP. It is observed that Indian SMEs (small & medium enterprises) can improve their performance in global manufacturing sector by adopting Lean manufacturing system. While implementation in Indian SMEs there are certain factors which are opposing the system to adopt lean manufacturing like lack of top management commitment, financial constraints, bureaucracy in organization, fear to adopt new technology, workers resistance etc. Earlier studies examined the benefits of Lean manufacturing adoption without considering the significant barriers in adoption in Indian SMEs. So the purpose of this study is to investigate the opposing factors in adoption of Lean manufacturing in Indian SMEs and systematically evaluate causal/effect barriers by Grey-DEMATEL technique. Result of this study show that nine out of fourteen belongs to casual group and five barriers are belongs to effect group.**

***Keyword* – Lean manufacturing, Grey-DEMATEL, SMEs, Barriers**

I. Introduction

Small & medium enterprises **(**SMEs) play an important role in both developed and developing countries. Emerging countries like India, SMEs are operating in a very challenging environment. SMEs have been the backbone of the Indian economy and occupy a prominent position in the well development of economy. Future economic growth and job creation within India is highly depending on SMEs. Over 48 million Indian SMEs have been growing at a stable speed of 4.5% from the last five years. 40% employment is provided by SMEs in India and contributing 45% to manufacturing sector output which are contributing only 17% to Indian GDP[1]-[2]. The main reason behind the SMEs contribution is low because lack of adoption of new manufacturing technology like Lean manufacturing. Objective of the Lean manufacturing is to identify and eliminate the root cause of unwanted waste which is not added any value to product and services. Over last decade developed countries are implementing Lean manufacturing to enhance their SMEs performance. So to stand in the competition, Indian SMEs should adopt Lean manufacturing. But in developing countries like India there are some potential challenges which are opposing the implementation of Lean manufacturing system in SMEs. These barriers should be removed for successfully implementation of Lean manufacturing and to enhance the overall performance of the SMEs. This paper considers internal as well as external barriers for Lean manufacturing adoption in Indian SMEs. This research study is relevant for those countries whose economy is highly dependent on SMEs. Some highlights of this research paper are listed below:

- To identify the internal as well as external barriers for Lean manufacturing adoption in Indian SMEs from various literature and by means of discussions with various academic and industrial experts.
- To propose a framework and methodology for analyzing barriers to Lean manufacturing adoption in Indian SMEs.
- To prioritizing the casual/effect barriers for Lean manufacturing adoption in Indian SMEs by Grey Decision Making Trial and Evaluation Laboratory (DEMATEL) techniques.

II. Barriers Identification

The first objective of this paper is to identify the barriers which are opposing to adopt of Lean manufacturing in all size of industry, then we select the barriers for small and medium enterprises. Initially Twenty four barriers were found in the preliminary result, derived from the literature. After several round of iterations through discussion and content verification with experts, the following fourteen barriers are chosen, those are listed in Table-1.

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TABLE 1
BARRIERS AND THEIR ADVOCATING AUTHORS

S.NO.	BARRIERS	NOTATION	AUTHOR
1	Lack of top management commitment	B1	[3]-[4]
2	Lack of mutual trust between management and employees	B2	[5]
3	Lack of Organizational infrastructure	B3	[6]
4	Lack of empowerment of employees	B4	[7]
5	Improper information sharing &communication gap between partners	B5	[8]-[3]
6	Lack of Training & Education program	B6	[8]
7	Unfavorable work environment and Culture	B7	[9]-[10]-[4]
8	Bureaucracy in organization	B8	Experts
9	Workers resistance	B9	[11]-[12]
10	Financial constraints	B10	[4]
11	Lack of multiskilled human resources	B11	[13]
12	Cross-functional conflicts	B12	[14]
13	Fear to adopt new technology	B13	[15]
14	Lack of awareness about Lean manufacturing benefits	B14	[16]

III. METHODOLOGY

This research study applies Grey-DEMATEL method to explore the interrelationships among the fourteen barriers to identify the critical barriers. The primary data used in the Grey-DEMATEL methodology was collected by the interviews of two industrial experts. A grey pair-wise influence comparison scale for the component is defined. In this research paper we used five level scale for the respondent which are shown in Table: 2

TABLE II
THE GREY LINGUISTIC SCALE FOR THE RESPONDENT'S EVALUATION

Mathematics notations

Normal values	Linguistic terms	Grey number
0	No influence	[0,0]
1	Very low influence	[0,0.25]
2	Low influence	[0.25,0.5]
3	High influence	[0.5,0.75]
4	Very high influence	[0.75,1]

K: the set of evaluators or decision makers;
I, J: The Index set of criterion;

$\otimes x_{ij}^{k}$: The gray number for an evaluator k, that will evaluate the influence of criterion i on the criterion j, $k \in K$, $i \in I$;

Y_{ij}^{k}: The total normalized crisp value for an evaluator k, where $k \in K$, $i \in I$;

z_{ij}^{k}: The final crisp values for an evaluator k, where $k \in K$, $i \in I$;

A: The initial relation matrix, where $A = \left[a_{ij} \right]_{i \times j}$, a_{ij} is denoted as the degree to which the criterion i affects the criterion;

A. Grey System Approach

Mathematical theory called a "grey" theory from a grey set was first proposed by Deng [17]. Grey system is an approach that can generate possible outcomes with small amount of data and they can integrate ambiguity and uncertaintiny into the assessment of the process. Three basic step are described as follows to get crisp value from grey number by an effective defuzzification method of converting fuzzy data into crisp score[18].

For a grey number $\otimes x_{ij}^{k} = [\underline{\otimes} x_{ij}^{k}, \overline{\otimes} x_{ij}^{k}]$, we can get the crisp values from the next three steps:

Step 1: Normalization

$$\underline{\otimes} \bar{x}_{ij}^{k} = (\underline{\otimes} x_{ij}^{k} - \min_{j} \underline{\otimes} x_{ij}^{k}) \Big/ \Delta_{\min}^{\max}$$

$$\overline{\otimes} \bar{x}_{ij}^{k} = (\overline{\otimes} x_{ij}^{k} - \min_{j} \underline{\otimes} x_{ij}^{k}) \Big/ \Delta_{\min}^{\max},$$

Where $\Delta_{\min}^{\max} = \max_{j} \overline{\otimes} x_{ij}^{k} - \min_{j} \underline{\otimes} x_{ij}^{k}$ (1)

Step 2: Determination of normalized crisp value

$$y_{ij}^{k} = \frac{\underline{\otimes} \bar{x}_{ij}^{k} \left(1 - \underline{\otimes} \bar{x}_{ij}^{k}\right) + \overline{\otimes} \bar{x}_{ij}^{k} \times \overline{\otimes} \bar{x}_{ij}^{k}}{1 - \underline{\otimes} \bar{x}_{ij}^{k} + \overline{\otimes} \bar{x}_{ij}^{k}} \quad (2)$$

Step 3: computation of final crisp value

$$z_{ij}^{k} = \min_{j} \underline{\otimes} x_{ij}^{k} + y_{ij}^{k} \Delta_{\min}^{\max} \quad (3)$$

B. DEMATEL Method

DEMATEL method was developed by the Science and Human affairs program of the Battelle Memorial Institute of Geneva in between 1972 to 1979, to solve complicate and intertwined Problems. DEMATEL has been accepted as one of the comprehensive tool to solve the cause and effect relationship among the evaluation criteria [19]. This research paper employed it as a MCDM tool in order to analyses the barriers in Lean manufacturing adoption in Indian SMEs.

DEMATEL involves following steps:

Step 1: Initial relation matrix "A"

The first step is to set up an initial relation matrix based on decision makers rating over given criteria.

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$$A=\begin{bmatrix} 0 & a_{12} & a_{13} & \cdots & a_{1(n-1)} & a_{1n} \\ a_{21} & 0 & a_{23} & \cdots & a_{2(n-1)} & a_{2n} \\ \vdots & \vdots & \ddots & \cdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ a_{(n-1)1} & a_{(n-1)2} & a_{(n-1)3} & \cdots & 0 & a_{(n-1)n} \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{n(n-1)} & 0 \end{bmatrix} \quad (4)$$

Step 2: Set up normalized direct-relation matrix "X"
The normalized direct relation matrix is obtained through equations (5) and (6). All elements in this matrix lie between 1 and 0.

$$X = K * A \quad (5)$$

$$K = \frac{1}{\max\limits_{1\le i\le n} \sum_{j=1}^{n} a_{ij}} \quad (6)$$

Where, X = Normalized direct relation matrix; K = the normalization factor; A = Initial relation matrix.

Step 3: Set up total relation matrix "M"
In this step we need to set up total relation matrix M. The normalized matrix is processed by the formula in equation (7) where I denote the identity matrix.

$$M = X(I - X)^{-1} \quad (7)$$

Step 4: Obtain sum of sum of rows and columns R denotes the sum of rows and D denotes the sum of columns which are shown in Table: 3 this should be calculated through equations (8) and (9)

$$R = \left[\sum_{j=1}^{n} m_{ij}\right]_{1\times n} \quad (8) \qquad D = \left[\sum_{j=1}^{n} m_{ij}\right]_{n\times 1} \quad (9)$$

TABLE III
DEGREE OF PROMINENCE AND NET CAUSE/EFFECT VALUES FOR LEAN MANUFACTURING ADOPTION IN INDIAN SMES.

Barriers	R	D	R+D	R-D
B1	3.78809	3.657905	7.445995	0.130185
B2	2.410064	2.825497	5.235561	-0.41543
B3	2.510173	2.257847	4.76802	0.252326
B4	2.355187	3.526109	5.881296	-1.17092
B5	2.771813	3.054769	5.826582	-0.28296
B6	2.68453	2.658307	5.342837	0.026223
B7	3.191214	3.119429	6.310643	0.071785
B8	2.555849	2.501621	5.05747	0.054228
B9	2.822624	2.723119	5.545743	0.099505
B10	3.021398	2.224769	5.246167	0.796629
B11	2.542202	3.480798	6.023	-0.9386
B12	2.571036	2.592633	5.163669	-0.0216
B13	3.411236	2.391274	5.80251	1.019962
B14	3.398918	3.020258	6.419176	0.37866

IV. Result and Discussion

This research paper reveals the prominence and net cause/effect values for barriers in lean manufacturing adoption in Indian SMEs. Here the casual factors are as follows: B13>B10>B14>B3>B1>B9>B7>B8>B6. In this casual factors B13 (Fear to adopt new technology) is ranked first in the cause group which indicates that B13 is the primary casual factor. Effect factors are shorted as follows: B12>B5>B2>B11>B4. These five factors are influenced by casual factors which oppose the adoption of Lean manufacturing in Indian SMEs. B12 (Cross-functional conflicts) is near to the cause group and is slightly influenced by casual factors. Finally, other barriers namely B5, B2, B11 and B4 are the barriers which have less influence on adoption of Lean manufacturing when compared to other casual factors.

V. Conclusion

This research paper contributes for identifying and prioritizing the interrelationships among barriers which are selected from the literature review and discussed with industrial experts on adoption of Lean manufacturing in Indian SMEs by applying the Grey-DEMATEL technique. All important perspective from the industrial experts are considered and explored in this study. Finally combined result is provided by integrating all experts viewpoint. The result of this research paper will help the emerging countries like India and their SMEs to keep focus on the listed critical barriers to enhance their productivity and growth. This study revealed that fear to adopt new technology is a high influencing barriers among all barriers.

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