Interpretive Structural Modeling of identified Barriers to Lean Implementation in SMEs

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Abstract. Lean practices are implemented in manufacturing companies and services to find hidden waste and attain continuous improvement. Various enterprises have experienced difficulties in the Lean implementation. Following the use of appropriate lean instruments and techniques, there are many other factors that affect success lean implementation process. Researchers have identified a huge number of barriers to implementation of Lean. Understanding the barriers and the interactions between them can be crucial to the success of lean implementation.
Interpretive Structural Modeling (ISM) is one of the established methodologies to bring forward the interrelationships among parameters of an issue or a problem.
Purpose- The purpose of this paper is to create the hierarchy of the various barriers to Lean Implementation according to their importance using the approach of ISM to facilitate Small and Medium enterprises (SMEs) across India. The study is specific to the Small and Medium Enterprises (SMEs) from India.
Keywords: Lean implementation, Small and Medium enterprises (SMEs), Interpretive Structural Modeling (ISM)

1. Introduction

Lean implementation is fast becoming popular in India and the world to eliminate the wastes within an organization and thus improve the performance. Lean strives to create an efficient operation and by bringing together the best practices and concepts of productivity and problem-solving.

It is difficult to move from a traditional production system to a Lean production system. This change requires attention for both processes and people. The availability of extensive documentation on the benefits of the lean manufacturing implementation could not extend it to a large number of companies.

The present study focuses on the barriers to the implementation of the Lean concept in Small and Medium Enterprises (SMEs) in India and to create the hierarchy of the various

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barriers to Lean Implementation according to their importance using the approach of ISM to facilitate SMEs across India. ISM methodology has been used in this study to understand and analyse contextual relations and hierarchical levels of barriers in the implementation of Lean.

The body of this paper is organized as follows. After Introduction in Section 1, section 2 presents the literature study on barriers to implementation of Lean. Section 3 explains the ISM methodology. Section 4 presents the details of the ISM approach to the barriers to implementation of Lean model. The discussion on the outcome of the study is presented in Section 5. And Section 6 presents the Conclusions.

2 Literature review

2.1 Background of Lean Implementation in SMEs

The Lean manufacturing is a manufacturing strategy that eliminates waste and increases the value of production activities to achieve a smooth flow of production. Without a Lean manufacturing strategy, an organization cannot succeed in today's global competition, where higher quality, faster delivery, and lower costs are needed [1].

Dora et al. [2] under a study examined the circumstances or key factors and their impact on limited production in small and medium enterprises. Its own characteristics, as well as the extremely volatile demand and supply, constitute barriers to the introduction of Lean processing. Unlike large companies, the environment of SMEs has a great resistance to adapt to change.

This study focuses on an analysis of the barriers to the implementation of the Lean approach in SMEs in India.

2.2 Barriers for adopting Lean in SMEs

The Literature survey has thrown light on various kinds of barriers that hinder an organization from going Lean. The critical obstacles to the implementation of the Lean have been examined by several researchers. Z. Radnor et al. [3] identified three problems that organizations face: the issue of people, the issue of the process and the issue of sustainability. In a similar type of classification by M. F. Bollbach [4], he explained the social and technical barriers that are necessary for the implementation of Lean. The obstacles in the Lean building were studied by H. M. Alinaitwe [5]. The obstacles to the introduction of lean health have been reviewed by L. Brandão de Souza and M. Pidd [6].

The findings derived from a research study by Jadhav et al. [7] led to the identification of 24 Lean barriers. The authors conclude that the success of the Lean implementation will not be completely based on the application of appropriate tools and techniques, but also on top management participation and leadership, attitude of employees, resources and organization culture.

According to a study [8] the small size of the enterprises, the traditional design and the rigid design make it difficult to implement the lean manufacturing in small and medium enterprises. The study also helps experts anticipate possible barriers and take the appropriate measures to address them in a lean implementation.

The most frequent problems enlisted by the researchers Mariusz Bednarek and Luis Fernando Niño Luna [9] include:

- Overcome the rigid corporate culture;
- Ignorance of the tools and methods of implementation;

- Efforts are focused on individual tasks instead of complex objectives or development of the business as a whole;
- Resistance to work;
- The use of unidentified models according to the characteristics of each company;
- Lack of an adequate implementation strategy;
- Lack of training and required skills;
- Lack of resources needed for lean implementation;
- Insufficient support for the Board of Directors and mid-level officials when projects are implemented.

Shrimali and Soni [10] have studied and ranked the barriers in the implementation of Lean Manufacturing and improve understanding with the Lean philosophy in small and medium enterprises in India. The researchers have presented the results of a survey conducted on the Indian SMEs with the main purpose of identify the barriers during the implementation of lean manufacturing practices and comparing these barriers. (Table 1).

Table 1. Results on Lean Implementation Barriers (Shrimali & Soni, 2017) [10].

S. No.	Factor	Mean	Rank
1	Resistance to Change the Middle Management	4.62	1
2	Lack of Flexible Working Arrangement	3.36	2
3	Absence of Lean Implementation Team	3.26	3
4	Lack of Reward System	3.17	4
5	Little Support from Top Management	2.37	5
6	Poor Lean Training	2.21	6
7	High Cost/Investment	2.08	7
8	Absence of Consultant	1.76	8
9	Other	1.69	9

The study shows that the biggest barriers in implementing lean manufacturing practices is Resistance to change by middle management and Absence of a lean implementation team or Lack of skilled people and followed by Lack of flexible working arrangements and Little Support from the top management.

3 Problem description

The study has taken the research of Shrimali and Soni [10] on the barriers to the implementation of Lean in SMEs as the base paper for this study. The total feedbacks analysed by the researchers are 149. The study mentions that out of the 149 responses analysed, 16 are from Medium sized, 127 are Small sized and 2 are Micro Enterprises belonging to different industry sectors.

This current paper aims to study, understand and analyze the contextual relations and hierarchical levels of barriers in implementation of Lean. The authors have used the interpretive structure modeling (ISM), an established method of identifying relationships between different parameters of the system.

The purpose of this paper is:

1. To identify the most critical barriers associated with the implementation of Lean in SMEs,
2. To determine the relationship between these identified barriers to implementation of Lean by means of interpretive structural modeling,
3. To suggest a structural model for the barriers to Lean Implementation, and
4. To organize the identified barriers in different categories using MICMAC analysis.

4 Solution methodology

4.1 Interpretive Structural Modeling (ISM)

The Interpretive structural modeling (ISM) is a process of interactive learning. Presence of indirect or direct-connected elements complicates the structure of any system. It is difficult to handle such a system, whose structure is not clearly defined. Therefore, a methodology is needed to identify a structure. Such a method is- Interpretive structural modelling. The various components of a process are analyzed in a comprehensive system model. There are many examples of the use of ISM in the research literature. The two basic concepts to understand the ISM system are- reachability and transitivity.

ISM's basic idea is to use the experts' practical experience and expertise to develop a complex system (element) into subsystems (elements) and create a multi-level structural model. The ISM method is the rule and guidance on the complexity of the relationship between the elements of the system elements [11, 12].

The various steps in the ISM methodology [13] are the following:

Step 1. The variables (criteria) are considered for the system under consideration.

Step 2. Based on the variables identified in step 1, a context relationship between the variables is established to determine which variables are to be examined.

Step 3. The structure of the personalized interaction matrix (SSIM) is developed for the variables, which indicates the pairing relationships between the variables of the evaluated system.

Step 4. The access matrix is developed from SSIM and the matrix transition is verified. The transition of a contextual relationship is a fundamental premise in ISM. It establishes that if variable A is related to B and B is related to C, then A is necessarily related to C.

Step 5. The scope matrix obtained in step 4 is divided into different levels.

Step 6. Based on the previous relationships in the availability matrix, an objective graphic is drawn and the transitive links are eliminated.

Step 7. The resulting digraph is converted to ISM by replacing the report node variables.

Step 8. The ISM model developed in step 7 is reviewed to verify the conceptual inconsistency and make the necessary adjustments. The previous steps are illustrated in Figure 2.

5 Application of ISM

ISM has been used by some researchers across the globe to develop a relationship among issues/enablers/barriers in different fields.

5.1 Data collection

The identified barriers taken under the study are from the base paper by Shrimali & Soni [10]. These barriers are-

1. Little Support from Top Management
2. Resistance to Change the Middle Management
3. Poor Lean Training
4. Absence of Lean Implementation Team
5. Lack of Flexible Working Arrangement
6. Absence of Consultant
7. Lack of Reward System
8. High Cost/Investment

5.2 Structural self-interaction matrix (SSIM)

In the first step towards generating a matrix, considering the contextual relationship for each variable, the existence of a relation between any two barriers (i and j) and the associated direction of the relation is questioned. Following four symbols are used to depict the direction of a relationship between the barriers (i and j):

V : Barrier i will promote barrier j;
A : Barrier j will promote barrier i;
X : Barrier i and j will promote each other; and
O : Barriers i and j are unrelated.

The SSIM for the barriers in the implementation of green supply chain is given in Table 2. The following section explains the use of the symbols V, A, X, and O in the SSIM.

Table 2. Structural Self Interaction Matrix (SSIM).

	i j	1	2	3	4	5	6	7	8
1	Less Support from Top Management		X	V	V	O	V	V	X
2	Resistance to Change the Middle Management			V	X	V	V	V	X
3	Poor Lean Training				A	O	O	O	X
4	Absence of Lean Implementation Team					V	O	O	A
5	Lack of Flexible Working Arrangement						O	O	A
6	Absence of Consultant							O	A
7	Lack of Reward System								O
8	High Cost/Investment								

5.3 Initial Reachability Matrix

The SSIM has been converted into a binary matrix, called the initial reachability matrix by substituting V, A, X and O by 1 and 0 as per the case. The substitution of 1s and 0s are as per the following rules:

i. If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0.
ii. If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.
iii. If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1.
iv. If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Table 3. Initial Reachability Matrix.

S.	i j	1	2	3	4	5	6	7	8
1	Less Support from Top Management	1	1	1	1	0	1	1	1
2	Resistance to Change the Middle Management	1	1	1	1	1	1	1	1
3	Poor Lean Training	0	0	1	0	0	0	0	1
4	Absence of Lean Implementation Team	0	1	1	1	1	0	0	0
5	Lack of Flexible Working Arrangement	0	0	0	0	1	0	0	0
6	Absence of Consultant	0	0	0	0	0	1	0	0
7	Lack of Reward System	0	0	0	0	0	0	1	0
8	High Cost/Investment	1	1	1	1	1	1	0	1

5.4 Final Reachability Matrix

After incorporating the transitivity as described in Step 4 of the ISM methodology, the final reachability matrix is shown in Table 4, the driving power and dependence of each variable is also shown. Driving power for each variable is the total number of variables (including itself), which it may help to achieve. On the other hand, dependence is the total number of variables (including itself), which may help in achieving it. These driving power and dependencies will be later used in the classification of variables into the four groups of autonomous, dependent, linkage and drivers (independent).

Table 4. Final Reachability Matrix.

S.	i j	1	2	3	4	5	6	7	8	**Driving Power**
1	Less Support from Top Management	1	1	1	1	0	1	1	1	7
2	Resistance to Change the Middle	1	1	1	1	1	1	1	1	8
3	Poor Lean Training	0	0	1	0	0	0	0	1	2
4	Absence of Lean Implementation Team	0	1	1	1	1	0	0	0	4
5	Lack of Flexible Working Arrangement	0	0	0	0	1	0	0	0	1
6	Absence of Consultant	0	0	0	0	0	1	0	0	1
7	Lack of Reward System	0	0	0	0	0	0	1	0	1
8	High Cost/Investment	1	1	1	1	1	1	0	1	7
	Dependence Power	3	4	5	4	4	4	3	4	**31**

5.5. Level partitions

The reachability and antecedent [14] for each barrier is obtained from the available final matrix. The reachability set for a given variable consists of the variable itself and other variables that it can help achieve. A set of antecedents consists of the variable itself and other variables that can help achieve them. Subsequently, the intersection of these sets is derived for all the variables. The variable for which the reachability and intersection sets are the same is given by the top level variable in the ISM hierarchy that would not help to achieve any other variable above its own level. After identifying the top-level element, the remaining variables are discarded. In this study, 8 barriers are presented together with their reachability set, background set, antecedent set and levels, as shown in Table 5. The process of identifying these barriers is completed in eight iterations.

This iteration continues until the levels of each variable are reached. The specified levels help build the digraph and the final ISM model (Fig 1).

Table 5. Iteration table for level partition.

S. No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,6,7,8	1,2,8	1,2,8	II
2	1,2,3,4,5,6,7,8	1,2,4,8	1,2,4,8	I
3	3,8	1,2,3,4,8	3,8	III
4	2,3,4,5	1,2,4,8	2,4	III
5	5	2,4,5,8	5	IV
6	6	1,2,6,8	6	IV
7	7	1,2,7	7	IV
8	1,2,3,4,5,6,8	1,2,3,8	1,2,3,8	I

Table 6. Driving power and dominance diagram for lean barriers.

8				2				
7	**Driving**		1	8		**Linkage**		
6								
5								
4				4				
3								
2	**Autonomous**				3	**Dependence**		
1			7	5, 6				
	1	2	3	4	5	6	7	8

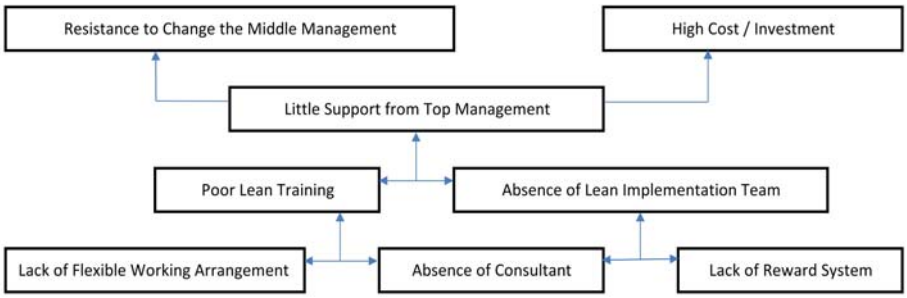

Fig. 1. ISM based model for barriers to lean implementation.

5.7 MICMAC analysis

Matriced' Impacts croises-multipication applique' and classment (cross-impact matrix multiplication applied to classification) is abbreviated as MICMAC. The MICMAC principle is based on multiplication properties of matrices [15]. The purpose of MICMAC analysis is to analyze the drive power and dependence power of enablers. This is done to identify the key enablers that drive the system in various categories. Based on their drive power and dependence power, the enablers, in the present case, have been classified into four categories as follows:

1. Autonomous enablers: These enablers have weak driving power and weak dependence. They are relatively disconnected from the system, with which they have few links, which may be very strong. These enablers are represented in Quadrant I.
2. Dependent enablers: This category includes those enablers which have weak drive power but strong dependence power and placed in Quadrant II.
3. Linkage enablers: These have strong driving power as well as strong dependence and are placed in Quadrant III. They are also unstable and so any action on them will have an effect on others and also a feedback effect on themselves.
4. Independent enablers: These have strong driving power but weak dependence power. These are represented in Quadrant IV.

6 Results and discussion

Autonomous variables generally appear as weak driver as well as weak dependent and are relatively disconnected from the system. These variables do not have much influence on the other variables of the system. Absence of lean implementation team, lack of flexible working arrangement, absence of consultant and lack of reward system are falling under

autonomous variable category and these are linked with each other in the structure. Thus, these are stable factors. While Little support of Top Management, Resistance to change from the middle management and Higher investment cost are driving the barriers. Emphasis is needed to resolve these barriers to ensure successful lean implementation.

7 Conclusions

To be more competitive a lean implementation should be well coordinated and responsive.

This paper developed a model to understand the barriers to Lean Implementation in SMEs. Although, ample literature is available on lean manufacturing and various issues related to it. The relationship between barriers to lean implementation in SMEs has not been modelled for manufacturing organizations. The present model will help managers and lean practitioners to understand the relationship in detail. This research assumes significant contribution in this regards.

This study has considered eight barriers. The interpretive structural modeling (ISM) approach has been employed to develop the structural relationship among these barriers. ISM approach helped in determining driving and dependence power of all variables. It is observed that 'resistance to change from the middle-level management', and 'high cost of investment' are major drivers for of lean barriers. Attention must be paid on these barriers to have proper lean practice.

The present study was aimed to bring forward the contextual relations and hierarchical levels of barriers in the implementation of Lean. This has brought forward the parameters responsible as drive factors among the barriers to the implementation of Lean in SMEs. Linear structural relationship can be developed between these lean barriers so as to test the validity of the barriers of such hypothetical models for future study.

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