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Hierarchical Framework of Organizational Factors for Lean Implementation in Indian Tyre Industry: an Interpretive Structural Modeling Approach

Vipul Gupta[1], Manoj Patwardhan[2] and Padmanav Acharya[3]

Abstract

The purpose of this study is to identify the organizational factors for successful lean implementation in tyre manufacturing industry. The key objective is to find out the interrelationship among the identified factors for developing effective lean manufacturing environment in a tyre manufacturing organization. This research is qualitative in nature where the opinion from group of experts of Indian tyre industry and academicians were consulted to formulate an Interpretive Structural Model (ISM) of the organizational factors of lean manufacturing implementation in a tyre manufacturing organization. Authors also incorporated Mic-Mac analysis to analyze the driving and dependence power of the identified factors.

This paper provides some key enablers for the successful implementation of lean tools in Indian tyre manufacturing, where lean practices are still in the early stage and little literature is available in this context with tyre manufacturing. Also an attempt has been made to incorporate corporate social responsibility *in this study, as an important parameter for developing lean environment.*

Keywords: *Interpretive Structural Modeling, Lean manufacturing, Mic-Mac analysis, Organizational factors, Tyre manufacturing.*

Introduction

Toyota Production System or Lean manufacturing (LM) is one of the most powerful model formulated till-date for efficient design and management of manufacturing operations. This system helped to grow Toyota Motor Corporation from a small truck-maker struggling in the era of World War II, to the world's third largest automaker by the end of the 1980's. US researcher John Krafcik (1988), studied and documented this approach and named it as "*lean manufacturing*" because of its capacity to do much more with fewer resources than traditional approaches. Even its critics note that other management practices similar to lean production have not been

1. ABV-Indian Institute of Information Technology and Management, Gwalior (M.P.), India
Contact no: +91-9713766023, E-mail: gupta.vpl9@gmail.com
2. Associate Professor
ABV-Indian Institute of Information Technology and Management, Gwalior (M.P.), India
Contact no: 0751-2449817, +91-9893454153, E-mail: manojp@iiitm.ac.in
3. Associate Professor
ABV-Indian Institute of Information Technology and Management, Gwalior (M.P.), India
Contact no: 0751-2449823, E-mail: pacharya@iiitm.ac.in

Corresponding Author
Dr. Manoj Patwardhan
Email: manojp@iiitm.ac.in Alternate, Email: mmp279@gmail.com

widely recognized and proliferated across the world (Dankbaar, 1997), and admit that "lean production will be the standard manufacturing mode of the 21st century" (Rinehart *et al*., 1997).

The main aim of incorporating Lean manufacturing environment in any industrial setup is to eliminate waste, reduce lead times and cost and thereby Improving productivity (Sriparavastu and Gupta, 1997; Shah and Ward, 2007). Therefore to achieve leanness, manufacturing companies around the world started incorporating so called "Technical aspects" like product/process standardization, automated manufacturing, integrated information system etc in their manufacturing system but did not succeeded in achieving expected growth in productivity.

In this regard many researchers argued that the transition from traditional to lean environment is largely related with organizational factors rather than just concentrating on the manufacturing or technical issues. Many of the studies on lean manufacturing implementation or transformation are not explicitly framing the relationship between organizational issues and lean manufacturing implementation. Although there are some reported studies that have developed some lean implementation models (Ahlstrom and Karlsson, 2000), but most of them mainly focuses on technical elements of the lean implementation.

However according to Karlsson and Ahlstrom(1996), the early phases of lean implementation may results in reduced productivity, which could cause discouragement amongst top management and employees therefore change management elements are needed to assess the changes taking place in the transition process of Lean manufacturing implementation. Therefore some researchers like Karlsson and Ahlstrom (1996), have taken "organizational factors" like top management commitment, organizational culture, Change management etc. into consideration and have developed some conceptual framework and case studies for the successful implementation of lean in manufacturing companies. It is also been explored in earlier case based studies that, Lean manufacturing techniques along with other tools like Six-Sigma can serve as a major instrument to reduce defects in the tyre manufacturing process in India (Gupta et.al, 2012). But still this area lacks extended research and must be taken care of with increased number of case based organizational studies in different geographical regions.

The objective of this paper is to develop the relationships among the "organizational factors" of lean implementation in tyre manufacturing organizations in India using interpretive structural modeling (ISM) and classify these critical success factors depending upon their driving and dependence power.

ISM is a well established methodology for identifying relationships among specific items which define a problem or an issue (Mandal and Deshmukh ,1994; Warfield, 2005).The judgment from group of experts are used in developing the relationship matrix, which is later used in the development of the ISM model. These Critical success factors or determinants of successful lean implementation are derived theoretically from different research studies pertaining to lean implementation (Table 1). Although different researchers have used different terminologies to indicate these factors, which are being designated by generic nomenclature in this study.

Organizational Factors for Lean Manufacturing

Previous researchers have studied lean manufacturing in various industries and in multiple domains and regions and have found several important drivers for the successful lean Implementation. Table 1 encapsulates the most important organizational factors of lean manufacturing process proposed by leading researchers whose papers got published in globally renowned journals which are indexed in Scopus and had fetch citation over 5 as on Jan 10, 2012. The number of citation indexed (Scopus) by each paper is mentioned against each author's name in the separate bracket.

ISM Methodology

ISM methodology suggests the use of the experts' opinions based on various management techniques such as brain storming, nominal technique, etc. in developing contextual relationship among the variables (Mohammed *et al*., 2008). Experts' opinions have been recommended and used by Mohammed *et al*. (2008), Mandal and Deshmukh (1994) and Saxena *et al*. (1992). The steps taken to achieve appropriate type of relationship are mentioned below:

Based on literature, eight determinants (Table 1) are retained for further analysis leaving *flexibility* because of its lower frequency of citation by previous researchers and on the basis of experts' opinion that tyre manufacturing is a process type industry where scope for flexible manufacturing system is very limited. These experts are being chosen from various tyre manufacturing industries and academicians on the basis of their experience and expertise.

Demographic details of these experts are listed in Table 2(a). Most of these experts suggested for incorporating, *Corporate Social Responsibility,* as an important dimension for lean implementation. Therefore in total nine factors tabulated in table 2 (b), are considered for doing further ISM analysis. These experts are arbitrary chosen from various Indian tyre manufacturing setups located in different part of the country.

Table 1: Critical Organizational Factors for Lean Implementation

Author/s, Year (Scopus Citation)☞ / Factors☟	Panizzolo R.,1998(28)	Genaidy and Karwowski, 2003 (26)	Doolen and Hacker,2005 (22)	Seth and Gupta,2005 (30)	Achanga et. al., 2006 (32)	Bhasin and Burcher,2006 (42)	Shah and Ward, 2007 (84)	Abdulmalek and Rajgopal, 2007 (62)	Sahoo et. al., 2008 (7)	Gurumurthy and Kodali, 2009 (6)
Top Management Commitment			✓	✓	✓	✓	✓		✓	✓
Organizational Culture	✓	✓		✓	✓	✓	✓	✓	✓	✓
Employee Commitment	✓	✓		✓	✓		✓	✓		✓
Organizational Communication	✓		✓	✓		✓	✓		✓	
Flexibility		✓			✓		✓			✓
Financial Capabilities				✓	✓			✓	✓	✓
Employee Skills Set	✓	✓	✓		✓	✓		✓		
Change Management		✓	✓			✓			✓	✓
Performance Improvement	✓		✓	✓	✓	✓	✓	✓	✓	✓

**() against each author in columns denotes the total number of citations indexed in scopus as on 05/01/2012*

Table 2 (a): Respondents Demography

Years of Experience		**# Respondents**
21 yrs and above		2
16-20 Years		2
11-15 Years		1
5-10 Years		2
Under 5 Years		Nil
Domain/ Department		**# Respondents**
Tyre Manufacturing	Production 1	
	Planning and Control	1
	Quality Assurance	2
Academia		2
Industry associations		1

Table 2 (b): Factor Abbreviation

Factor No	Factor Description	Factors Notation
1	Top Management Commitment	**TMC**
2	Organizational Culture	**OC**
3	Employee Commitment	**EC**
4	Organizational Communication	**COM**
5	Corporate Social Responsibility	**CSR**
6	Financial Capabilities	**FC**
7	Employee Skills Set	**ES**
8	Change Management	**CM**
9	Performance Improvement	**PI**

(A) Structural Self-interaction Matrix (SSIM)

A structural self-interaction matrix (SSIM) is formulated for determinants on the basis of expert opinion as shown in table 3, which indicates their pair-wise relationship.

Following notations are used to denote the inter-relationship among the determinants:

V - Determinant i will help to attain determinant j;

A - Determinant j will help to attain determinant i;

X - Determinant i and j will help to attain each other; and

O - Determinant i and j are not related

Table 3: Structural Self-interaction Matrix (SSIM)

Factor No	Factor Description	Factors Notation							
		PI	CM	ES	FC	CSR	MCO	EC	OC
1	Top Management Commitment	**V**	**V**	**V**	**A**	**V**	**V**	**V**	**V**
2	Organizational Culture	**O**	**V**	**X**	**A**	**V**	**X**	**X**	
3	Employee Commitment	**O**	**V**	**X**	**A**	**V**	**A**		
4	Organizational Communication	**V**	**V**	**X**	**A**	**V**			
5	Corporate Social Responsibility	**X**	**A**	**O**	**A**				
6	Financial Capabilities	**V**	**O**	**V**					
7	Employee Skills Set	**V**	**O**						
8	Change Management	**V**							
9	Performance Improvement	**X**							

(B) Reachability Matrix

Reachability matrix is developed from SSIM .The SSIM is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X and O by 1 and 0 as per rules stated below (Singh and Kant, 2008; Mandal and Deshmukh, 1994). The rules used for substitution are:

1. If the (i, j) entry in SSIM is V, then the (i, j) entry in reachabilty matrix becomes 1 and the (j, i) entry becomes 0.

2. If the (i, j) entry in SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.
3. If the (i, j) entry in SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1.
4. If the (i, j) entry in SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Following these rules, initial reachability matrix for determinants is obtained (Table 4).

Table 4: Initial Reachability Matrix

Factor No	Factor Description	Factors Notation								
		TMC	OC	EC	COM	CSR	FC	ES	CM	PI
1	Top Management Commitment	1	1	1	1	1	0	1	1	1
2	Organizational Culture	0	1	1	1	1	0	1	1	0
3	Employee Commitment	0	1	1	0	1	0	1	1	0
4	Organizational Communication	0	1	1	1	1	0	1	1	1
5	Corporate Social Responsibility	0	0	0	0	1	0	0	0	1
6	Financial Capabilities	1	1	1	1	1	1	1	0	1
7	Employee Skills Set	0	1	1	1	0	0	1	0	1
8	Change Management	0	0	0	0	1	0	0	1	1
9	Performance Improvement	0	0	0	0	1	0	0	0	1

(C) Transitivity Matrix

The final reachability matrix is obtained by incorporating the transitivity whereby, if element i reach to element j and element j reaches to element k than element i should reach to element k. Table 5 is obtained from Table 4 by corroborating transitivity. The driving power for each determinant is the sum of total determinants (including itself), which it may help to achieve. Dependence is the sum of total determinants (including itself), which may help achieve it (Jyoti et.al.2010). The driving power and dependency of each determinant to be used in MICMAC analysis are also shown in the same Table 5.

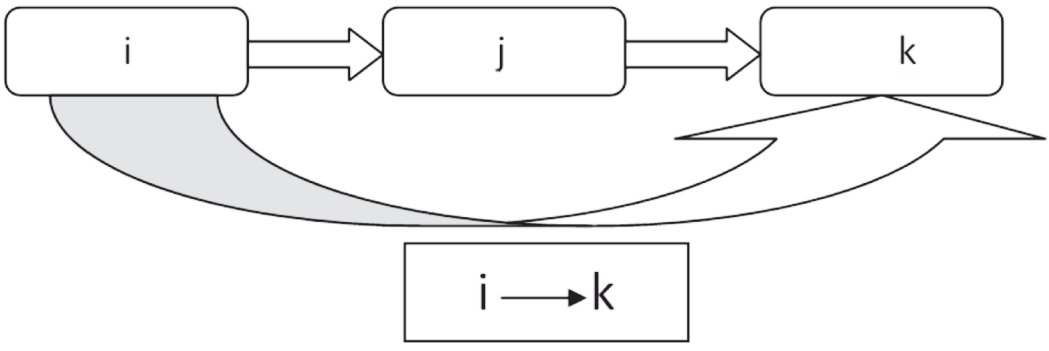


Figure 1: Transitivity Check

Table 5: Transitivity Matrix

Factor No	Factor Description	Factors Notation									Driving Power
		TMC	OC	EC	COM	CSR	FC	ES	CM	PI	
1	Top Management Commitment	1	1	1	1	1	0	1	1	1	8
2	Organizational Culture	0	1	1	1	1	0	1	1	1*	7
3	Employee Commitment	0	1	1	1*	1	0	1	1	1*	7
4	Organizational Communication	0	1	1	1	1	0	1	1	1	7
5	Corporate Social Responsibility	0	0	0	0	1	0	0	0	1	2
6	Financial Capabilities	1	1	1	1	1	1	1	1*	1	9
7	Employee Skills Set	0	1	1	1	1*	0	1	1*	1	7
8	Change Management	0	0	0	0	1	0	0	1	1	3
9	Performance Improvement	0	0	0	0	1	0	0	0	1	2
	Dependence Power	2	6	6	6	9	1	6	7	9	

Note: (*) shows the transitive relationship of the elements

(D) Level Partitioning

The transitivity matrix obtained in Step (C) is zoned off into different levels. The reachability set and antecedent set for each parameter are found out from final reachability matrix (Warfield, 1974). The reachability set for a particular determinant consists of the determinant itself and the other determinants, which may help in achieving them.

Then, the common elements of both reachability set and antecedent set is derived as intersection sets for all variables. The variables for which the reachability and the intersection sets are the same are named as level I (top level) in ISM hierarchy, which would not help achieve any other determinant above their own level.

Table 6: Level I

Factor No.	Factor Name	Reachability Set	Antecedent Set	Intersection	Level
1	Top Management Commitment	1,2,3,4,5,7,8,9	1,6	1	
2	Organizational Culture	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	
3	Employee Commitment	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	
4	Organizational Communication	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	
5	Corporate Social Responsibility	5,9	1,2,3,4,5,6,7,8,9	5,9	I
6	Financial Capabilities	1,2,3,4,5,6,7,8,9	6,	6	
7	Employee Skills Set	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	
8	Change Management	5,8,9	1,2,3,4,6,7	8	
9	Performance Improvement	5,9	1,2,3,4,5,6,7,8,9	5,9	I

After the designation of the top-level determinant, it is disposed off from the remaining rows. The iterative procedure continues till all levels are found out. The determinants, along with their reachability set, antecedent set, intersection set and the levels, are shown in Tables 7.

Table 7: Consolidated Level Hierarchy

Factor No.	Factor Name	Reachability Set	Antecedent Set	Intersection	Level
1	Top Management Commitment	1,2,3,4,5,7,8,9	1,6	1	IV
2	Organizational Culture	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	III
3	Employee Commitment	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	III
4	Organizational Communication	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	III
5	Corporate Social Responsibility	5,9	1,2,3,4,5,6,7,8,9	5,9	I
6	Financial Capabilities	1,2,3,4,5,6,7,8,9	6,	6	V
7	Employee Skills Set	2,3,4,5,7,8,9	1,2,3,4,6,7	2,3,4,7	III
8	Change Management	5,8,9	1,2,3,4,6,7	8	II
9	Performance Improvement	5,9	1,2,3,4,5,6,7,8,9	5,9	I

Table 8 represents overall level hierarchy which helps in building the lower triangular matrix and the final model of ISM.

Table 8: Lower Triangular Matrix

Factor No	Factor Description	Factors Notation								
		CSR	PI	CM	OC	EC	COM	ES	TMC	FC
1	Corporate Social Responsibility	1	1	0	0	0	0	0	0	0
2	Performance Improvement	1	1	0	0	0	0	0	0	0
3	Change Management	1	1	1	0	0	0	0	0	0
4	Organizational Culture	1	1	1	1	1	1	1	0	0
5	Employee Commitment	1	1	1	1	1	1	1	0	0
6	Organizational Communication	1	1	1	1	1	1	1	0	0
7	Employee Skills Set	1	1	1	1	1	1	1	0	0
8	Top Management Commitment	1	1	1	1	1	1	1	1	0
9	Financial Capabilities	1	1	1	1	1	1	1	1	1

(E) MICMAC Analysis

The MICMAC analysis is used to analyze the driver and dependency power of determinants. The driving power and dependence of each determinant is shown in Table 5.

The main objective of MICMAC analysis is to analyze the driver power and the dependency of the variables (Mandal and Deshmukh, 1994). The success factors mentioned earlier are categorized into four clusters as shown in Figure 2. The first cluster is known as "*autonomous cluster*" that have elements with weak driving power and weak dependence. In present study there is no element in this cluster. These elements are relatively disconnected from the system, and therefore are to be ultimately discarded from the model. In present study there is no such element in this cluster. Therefore it may be assumed that all factors considered in this study are important in context with lean manufacturing implementation.

The "*independent cluster*" as shown in figure 2 constitutes the most important variables with strong driving power but weak dependence. In this study *Financial Capability and Top Management Commitment* constitutes independent cluster. These factors are actually represents as the name suggests a set of variables which ultimately control other factors to develop lean manufacturing environment in an organization.

The "*linkage cluster*" has elements with strong driving power and strong dependence. Determinants

in this category are *Organizational Culture, Employee Commitment, Organizational Communication, and Employees Skills Set.* These factors, as the name suggests, acts as the mediator for developing lean manufacturing in this context and are being controlled by independent factors and help in developing dependent factors.

The "*dependent cluster*" constitutes the elements with weak driving power but strong dependence. *Change Management, Performance Improvement, Corporate Social Responsibility* belongs to this cluster. These are those factors which show the overall impact of lean manufacturing paradigm on the overall working of the organization. Therefore dependent cluster identifies the factors which can acts as the indicator of extent of lean manufacturing implementation in an organization.

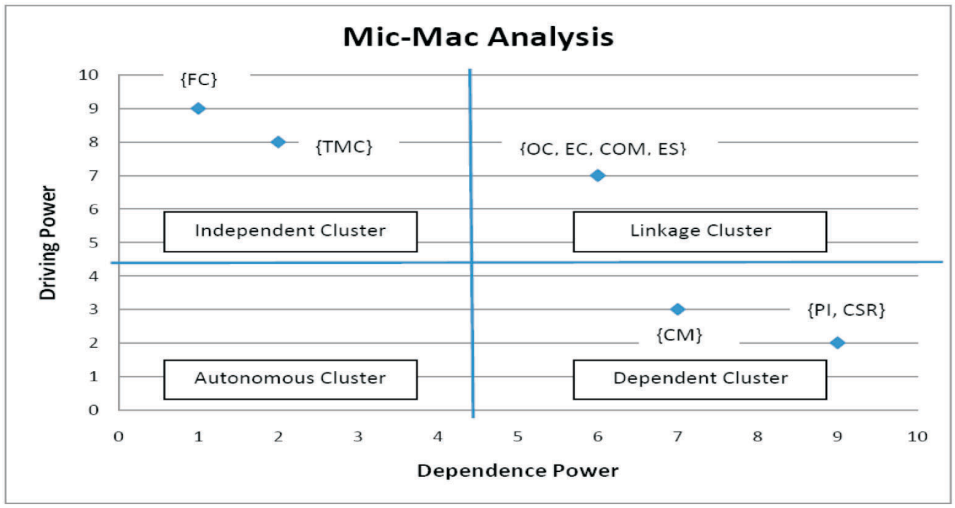
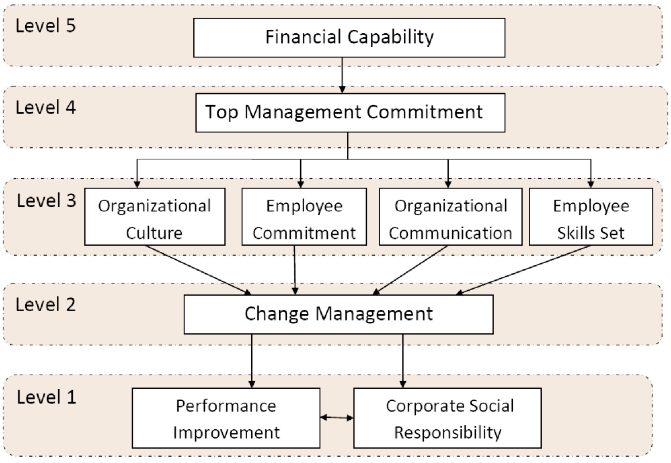


Figure 2: Classification of Factors

(F) ISM Based Model for Lean Implementation

On the basis of level partitioning shown in table 7, Interpretive Structural Model (ISM, figure 3), can be drawn which hierarchically categorize the factors considered in context with lean implementation. A higher level represents higher hierarchy which drives the factors lying in lower levels of hierarchy. From ISM it can be observed that financial capability and Top management commitment constitutes higher levels in the hierarchy of factors. The same had already being confirmed using Mic-Mac analysis. It can also be observed from the said ISM that, organizational culture, employees and communication are the key enables for bringing about any kind for change in an organization whose impact is ultimately visible in organization's performance and social status.



Discussion

Tyre manufacturing is an inevitable component of automobile industry. According to a recent report from Society of Indian Automobile Manufacturers (SIAM), the cumulative production data for April-January 2012 shows overall production growth of 14.56 percent over same period last year. Production in January 2012 registered growth of 11.25 percent as compared to January 2011. However the Indian automobile manufacturer's contribution in global terms is very low. This shows that potential for demand in tyres is huge and India have the potential for improving their performance in tyre manufacturing sector and contribute to the local as well as global markets. The major facilitator in this regard for Global competiveness is to produce high quality tyres in a cost effective manner. Development of Lean manufacturing environment can serve as the rescue operation for this sector as is evident from the views of experts opinion collected for the subject matter of this study.

This study suggests that Financial Capability of an organization builds strong perception and commitment of Top management for incorporating lean environment. These finding had also been validated by previous researchers (Doolen and Hacker, 2005; Gurumurthy and Kodali, 2009). Further according to this study Organizational Culture and Employees motivation are the key enables for incorporating Change management practices without which it is impossible to even think of implementing lean manufacturing paradigm in any organization (Karlsson and Ahlstrom, 1996; Bhasin and Burcher, 2006).

Major contribution of this study is the analysis of interaction among the critical success factors of Lean implementation in Indian tyre manufacturing setup and development of a framework using ISM. It identifies the level of hierarchy and inter-relationship of the factors which help the strategic managers to take actions in order to improve the performance of their organization. The driving and dependence power matrix (Figure 2) gives some key insights about the relative importance and interdependencies among success factors.

Implication and Conclusion

In the present research, the proposed ISM-based model for identification and ranking of Lean organizational factors can provide the decision makers and practitioners a more realistic representation of the organizational factors in the course of implementing Lean Manufacturing in tyre manufacturing organizations in India. A major contribution of this research paper lies in the development of contextual relationship among various identified determinants of Lean Manufacturing through a single systemic framework. The utility of the proposed ISM methodology may be put forth to allocate maximum resources to the dependent factors so as to develop conducive environment for Lean manufacturing implementation and therefore to better utilize their constrained resources.

Further, the systematic framework proposed in this study has broad application and can be used a road map to improve and monitor performance, administrative abilities, and corporate social responsibilities of the organization. There are conditions in which the success or failure of groups and organizations will be incorrectly attributed to the organizational factors, rather than to environmental forces over which the management have no control. In corporate world and in social movements, organizational forces play a critical role, and as such, is an important subject for study and research.

Even today, there is a rich variety of possibilities, which leads to our conclusion that the organizational factors should depend on the purposes to be served by the definition. One complex definition that has evolved, particularly to help understand a wide variety of research findings, delineates organizational factors as the interaction among members of a group that initiates

and maintains improved expectations and the competence of the group to solve problems or to attain business goals.

Effective functioning of business organization varies among cultures, whereas stakeholders in all the organizations must lead, motivate and make decisions using organizational factors as a base. Far from learning only one way of functioning in the organization, managers working across culture must become flexible enough to adapt to each particular situation.

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Appendix 1: Survey on Critical Success Factors- ISM Formulation for Lean Implementation in Indian Tyre Manufacturing Organizations

The following questionnaire is a self-administered assessment of your opinion about the critical success factors in regard with LEAN Manufacturing implementation or LEAN business methodology/approach that eliminates waste, adds customer value and continually improves its performance.

This questionnaire is a tested method and a proven analytical tool to help you advance your business' performance. The information you complete is for confidential academic use between your company and us. Its contents will not be discussed, shared or viewed by others.

Please complete the questionnaire as best you can with as complete details as possible. If a question is not relevant, just mark in N/A (Not Applicable). If you do not have answers to any question, or you do not understand the question, please feel free to discuss or we will discuss them with you later if it is necessary.

Section I: Respondent's Demography

1. Name:_____
2. Designation :_____
3. Contact Details (Email ID / Mob No.):_____
4. Experience in present Organization (In Yrs):_____
5. Total industry experience(in Years):_____
6. Are you aware of the Lean manufacturing tools and techniques (Yes/ No):_____

Section II. Organizational Demography

1. Name of the company: _____

2. Location of the company:

_____

3. Company was established in year:

_____

4. Major products of your company (Mention at least one)

_____

5. **Number of employees (Choose one):**

- 1 to 3
- 4 to 10

- 11 to 50
- 51 to 100
- 101 to 249

6. Products of your company are sold (Choose one):

- Mainly (More then 70%) in the local Market
- Mainly (over 50 %) in other cities
- Mainly (over 50 %) in other states
- Mainly (over 50 %) is exported to other countries

7. Net sales of your company (year 2011, in Rs)

- 5 Lac- 25 Lac
- 25 Lac-1 crore
- 1 crore-10 crore
- 10 Cr-25 Cr
- Over 25 Cr

Section III: ISM Methodology

Interpretive Structural Modeling (ISM) methodology suggests the use of the experts' opinions based on various management techniques such as brain storming, nominal technique, etc. in developing contextual relationship among the factors.

Factors based on literature are listed in following table for further analysis on the basis of your kind opinion. Therefore you are requested to mark following notations in respective blocks.

V - Factor i (row elements) will help to attain Factor j (Column elements);

A - Factor j will help to attain Factor i;

X - Factor i and j will help to attain each other; and

O - Factor i and j are not related

FACTORS	j: ☞ / i ☟	PI	CM	ES	FC	CSR	COM	EC	OC	TMC
Top Management Commitment	TMC									
Organizational Culture	OC									
Employee Commitment	EC									
Organizational Communication	COM									
Corporate Social Responsibility	CSR									
Financial Capabilities	FC									
Employee Skills Set	ES									
Change Management	CM									
Performance Improvement	PI									

Authors Biography

Vipul Gupta is a full time research scholar in management at Indian Institute of Information Technology and Management (ABV-IIITM), Gwalior. He holds a B.E. (Mechanical Engineering) degree from Madhav Institute of Technology and Science, Gwalior and Masters in Business Administration (MBA) from ABV-IIITM,Gwalior. He is presently pursuing his PhD from ABV-IIITM, Gwalior on determinants of successful Lean Implementation in Indian Industries. He has more than 4 years of Industrial experience before joining Ph.D. His areas of interest are: operations research, decision modeling, and lean manufacturing. Vipul Gupta is the corresponding author and can be contacted at: gupta.vpl9@gmail.com or vipul@iiitm.ac.in

Dr. Manoj Patwardhan is an Associate Professor in Management at Indian Institute of Information Technology and Management (ABV-IIITM), Gwalior. He has obtained his Masters Degree in Personnel Management and Industrial Relations in 1992 and subsequently a Doctorate degree in Management in 2004. His thesis work was mainly based on identification of Business Leadership traits and Organizational Effectiveness. He has worked in Industry for more than six years in Mumbai and Daman. Dr. Patwardhan has over 11 years of experience in teaching and research. He has many research papers in National and International journals to his credit. In the year 2002, his paper on Leadership was adjudged as the Best paper in The European Applied Business Research conference at Germany. Contact him at ABV-IIITM Gwalior-474010, India, email- manojp@iiitm.ac.in or mmp279@gmail.com

Dr. Padmanav Acharya is an Associate Professor in Management at Indian Institute of Information Technology and Management (ABV-IIITM), Gwalior. He received his M.Tech and Ph.D. from the Department of Industrial Engineering and Management at Indian Institute of Technology, Kharagpur, India. Dr. Acharya has nearly two decades of experience in teaching and research. His research interests include software project management, software engineering, system dynamics and operations management. Contact him at ABV-IIITM Gwalior-474010, India, email- pach67in@yahoo.com or pacharya@iiitm.ac.in