A Contextual Relationship Structural Model for Practicing Lean Production System in Indian SME

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Abstract

The Small and Medium-sized Enterprises (SMEs) sector plays a crucial role in the socio-economic development of any country, especially in today's globalized environment. SMEs act as potential sources of employment generation and economic growth. However, these enterprises often face threats from larger organizations, since they may directly or indirectly act as ancillary units to these larger players. In order to remain competitive in both domestic and global markets, SMEs need to recognize the value of their products and services from the customers' perspective. Additionally, they must eliminate non-value activities in their production processes and focus on improving profitability through various manufacturing strategies Among the numerous of manufacturing strategies available, the Lean Production System (LPS) has consistently been identified as the most effective method or strategy for enhancing operational efficiency. Although there have been numerous success stories of LPS implementation across various industries, many SMEs still struggle to embrace LPS in their operations in order to gain a competitive edge. Furthermore, there is a lack of suitable structural models or frameworks for implementing LPS specifically in SMEs. This study aims to develop a generalized contextual relationship structural model for implementing LPS in Indian SMEs. To address this issue, a three-phase research methodology is employed. In the first phase, all enablers/factors are identified through a comprehensive literature review and Pareto analysis (PA). Based on these identified factors, a contextual relationship structural model is constructed using the Total Interpretive Structural Modeling (TISM) approach in the second phase. Finally, the output of TISM is used to classify the factors based on their impact on other factors using the MICMAC methodology. This leads to the development of a House of Lean model (HOL). The proposed contextual relationship structural model, along with HOL, is expected to enhance the understanding of implementing LPS in SMEs for both academicians and practitioners.

Keywords

Lean Production System, Factors, Contextual Relationship Structural Model, Total Interpretive Structural Modelling, House of Lean Model

1. Introduction

The Small and Medium-sized Enterprises (SMEs) sector has emerged as an immensely high-spirited and energetic sector of the Indian economy over the last five decades. It has played a significant role in the country's socio-economic development by creating large SMEs considered pillars of the Indian economy. These SMEs act as potential sources of employment generation and economic growth. The progress of globalization has provided extensive opportunities not only to large organizations but also to SMEs globally. Due to globalization, companies can now communicate more efficiently across boundaries, reaching a more extensive customer base and transporting goods and services faster and easier. While exploring the benefits of globalization, large-sized organizations often pose a significant threat to MSMEs (Masroora and Asim 2019) since many SMEs directly or indirectly function as ancillary units to these large organizations. To remain competitive in domestic and global markets, SMEs must recognize the value of their products and services from the customer's perspective. They should also eliminate non-value activities by employing various manufacturing strategies in the production process to improve their organization's profit (Alkhoraif et al. 2019). Among the different manufacturing strategies discussed in the literature, Lean Manufacturing (LM) or LPS (Lean Production System) is becoming increasingly important regardless of industry size. The main objective of LPS is to produce a higher-quality product at the lowest possible cost and in the shortest time by eliminating waste. There are seven types of waste associated with LPS, including overproduction, inventory, waiting time, overprocessing,

transportation, motion, and defects (Chaple et al. 2021; Sharma et al. 2020; Goshime et al. 2019; Melton 2005). These wastes are categorized as non-value-added activities in LPS, highlighting the importance of effective implementation of LPS in SMEs. To achieve this, SMEs are voluntarily or forcibly adopting LPS to enhance organizational efficiency and sustain themselves amidst fierce competition. Implementing LPS in an organization involves numerous enabling factors that play a crucial role. Therefore, it is essential to identify the factors that facilitate the effective implementation of LPS in SMEs. Hence, the research questions addressed in this study are:

RQ1) What are the vital factors for effectively implementing LPS in SMEs.?

RQ2) How are the factors of LPS interrelated among them?

RQ3) How do we employ the interrelationship among factors for effective implementation ***of LPS in SMEs?***

This study addresses the above three research questions. Accordingly, the paper is structured as follows: Section 2 explains the proposed research methodology to address the above 3 research questions. Section 3 demonstrates the workability of the research methodology explained in section 2 using the data collected to address the study. Section 4 presents the conclusions, and managerial implications.

2. Proposed Research methodology

A three-phase research methodology is proposed to address each of the 3 research questions considered in this study and the same is briefly mentioned in Table 1:

Table 1. Research Question wise the Proposed Research Methodology

Phase	Research Question	Proposed Research Methodology
1	What are the vital factors for effectively implementing LPS in SMEs.?	Analysis of the closely related literature review and Pareto Analysis
2	How are the factors of LPS interrelationships among them?	Total Interpretive Structural Modelling (TSM) Approach
3	How do we employ the interrelationship among factors for effective implementation of LPS in SMEs?	MICMAC analysis and construction of House of Lean (HoL)

3. Demonstration of the workability of the Proposed Research Methodology

Phase 1 - Analysis of the closely related literature review and Pareto Analysis:

To determine the factors of LPS, the research process begins by selecting databases to extract relevant literature. Databases such as Science Direct, Emerald Insights, Google Scholar, Taylor and Francis, and Web of Science are explored. Keywords such as Lean and SME, Lean Manufacturing and SME, Lean Production System and SME, Lean Critical Success Factor and SME, Lean Factors and SME, etc., are employed to collect all the possible and a comprehensive range of closely related literature to identify the factors which are expected to influence the implementation of LPS in SMEs. In this study, articles published from 1990-2022 are examined to identify the factors of LPS in SMEs. With this premise and from the analysis of the literature, 78 existing and closely related research studies are identified. Further from the focused analysis of these 78 research articles with an objective of understating the factors which are expected to influence the implementation of LPS in SMEs, 32 unique factors are identified and the same is given in Table 2. From the analysis of the 78 research articles, it is observed that different subset of the identified 32 factors is only considered while implementing LPS in SMEs. That is, there is no study considered all the 32 factors while implementing LPS in SMEs. Though from the analysis of the literature all the 32 factors are relevant while implementing LPS in SMEs, managing many factors is practically difficult. To reduce this type of practical difficulty, researchers/practitioners generally follow the Pareto Analysis (Sreedharan et al.2018; Karupusamy and Gandhinathan,2006) to identify only 'Vital Factors' for the practical consideration. Accordingly, the required Pareto Analysis is carried out, considering all the 32 factors and the 78 studies associated with that, and the results of the Pareto Analysis is presented in Figure 1. From the Figure 1, the 16 Factors, presented in Table 3 are identified as Vital Factors and these need to be importantly considered while implementing LPS in SMEs.

Table 2. Identified unique factors of LPS in SMEs as per the Analysis of the 78 Research Articles

Identified 32 Unique Factors			
Commitment and support from top Management	Financial capabilities	Focus Customer	Involvement of supplier and customer
Training and education	Understanding of lean tools and its techniques	Incentives and Rewards	Project Management Skill
Organization Cultural Change	Performance Measurement and quick feedback response	Strong relationships with suppliers and customer	Appropriate selection of Lean perimeter
Involvement of all employees	Lean consultant	Standardization and capitalization of best practices	Ergonomic improvement
Shared improvement vision	Availability and Allocation of resources	Link quality initiatives to customer, supplier, and business	Quality management
Effective Communication	Teamwork	Motivation of employee	Cost Reduction
Effective Leadership	Continuous improvement	Proper Methodology of Lean Implementation	Reduced lead time
Competence and expertise	Empowerment of all employees	Organisation infrastructure and facilities layout configuration	Sufficient market knowledge

Table 3. Vital factors of LPS in SMEs as per the Pareto Analysis

Factor Code	**Name of the Factor**	**Factor Code**	**Name of the Factor**
E1	Commitment and support from top Management	E9	Performance measurement and quick feedback system
E2	Shared improvement vision	E10	Training and educations
E3	Effective leadership	E11	Empowerment of All Employees
E4	Effective communication	E12	Involvement of all employees
E5	Financial capabilities	E13	Organization CulturalChange
E6	Availability and allocation of resources	E14	Understanding lean tools and their techniques
E7	Skills and expertise	E15	Lean consultant
E8	Teamwork	E16	Continuous improvement

Phase 2 - Total Interpretive Structural Modelling (TISM) Approach:

To determine the contextual relationship between the identified 16 lean vital factors (presented in Table 3), the Total Interpretative Structural Modelling (TISM) approach, as developed by Sushil in 2012, is followed. To develop the required contextual relationship model (a conceptual framework or a structural mode), 25 respondents (comprising of 9 industry experts and 16 academic experts) have been asked to determine the relationship between the factors individually. For instance, they were asked "Yes or No" answer, if factor E1 - Commitment and support from top management influences factor E2 - shared improvement vision. In this study, each of the 25 respondents answered 240 questions [(16x15)/2), taking into account the 16 factors under consideration. Further, the summary of 25 respondents' score on "Yes or No" is considered following simple rule: If 13 or more out of the 25 respondents' answer is "Yes" then the summary of important of the specific item is entered as "Y" in the data developed for this

TISM approach. Accordingly, the basic data used for TISM approach after collecting individual respondent "Yes or No" score is given in Table 4. With this data, the TISM approach is followed and proposed a structural model (a conceptual model) and the same is given in Figure 2. According to the Figure 2, the identified 16 vital factors are structurally organized in to 12 levels with the Factor: E16 – Continuous Improvement be in the top level and the Factor: E5 – Financial Capability be in the 12th level (bottom level).

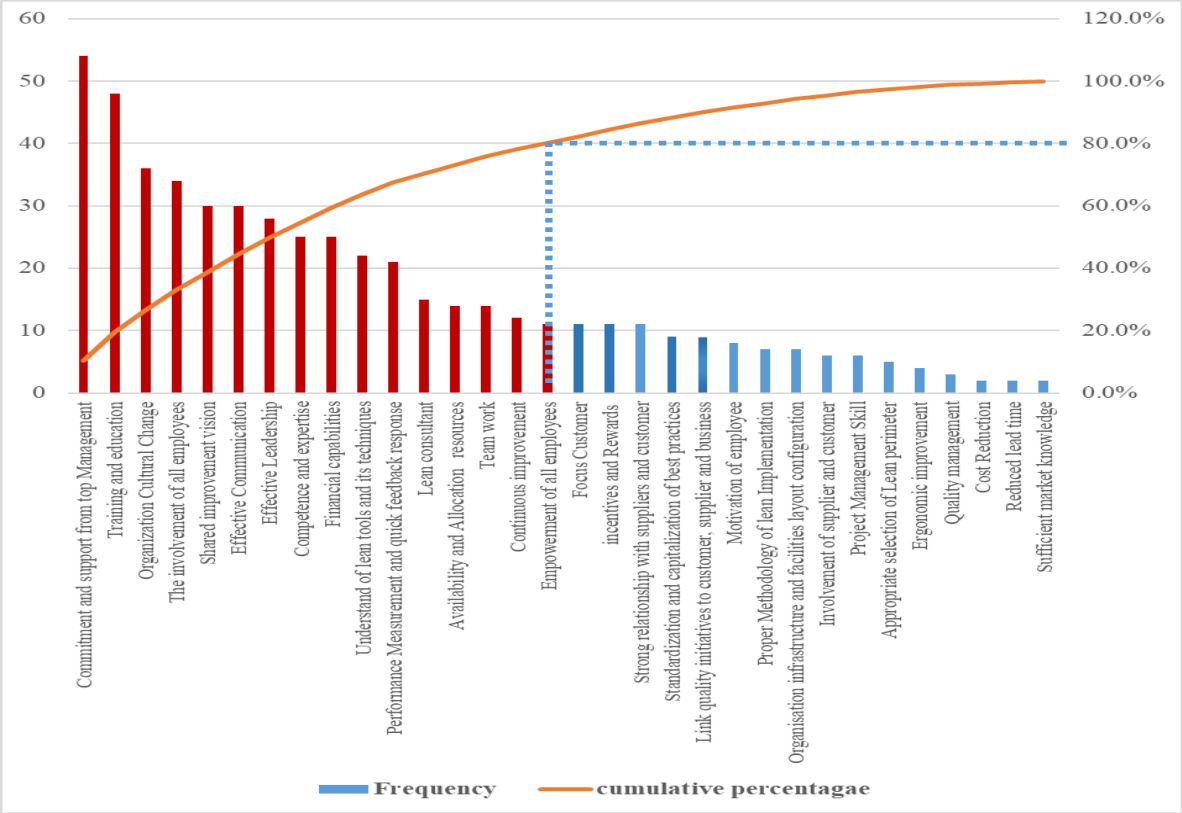

Figure 1. A Pareto Diagram, considering the Unique Factors involved in Implementation of LPS in SMEs

Phase 3 - MICMAC Analysis and Construction of House of Lean (HoL):

The primary objective of conducting MICMAC analysis is to evaluate the driving power and dependence of vital factors, specifically to identify the vital factors that play a critical role in the overall process. For this the data collected for TISM approach is used and carried out the MICMAC analysis. Then the vital factors are categorized into four clusters: Cluster I consist of autonomous factors, Cluster II comprises dependent factors, Cluster III includes linkage factors, and Cluster IV consists of independent factors. This categorization is depicted in the Figure 3 and is explained further as follows:

Cluster I - represents autonomous factors that have weak driving and dependence power. These factors include a shared improvement vision, performance measurement, and a quick feedback system.
Cluster II - represents dependence factors, which have strong dependence and driving power. These factors include skills and expertise, involvement of all employees, empowerment of all employees, organizational cultural change, and understanding of lean tools and techniques.
Cluster III - there are no factors identified in this cluster, implying that there are no factors with strong driving and dependence power.
Cluster IV - represents independent factors that have strong driving power and weak dependence power, which drives the entire system. Factors in this cluster include financial capabilities, commitment and support from top management, effective leadership, training and education, and availability and allocation of resources.

Table 4. The basic data considered for TISM Approach

No	Pairwise comparison	Aggregate score of Y	Aggregate Score of N	Final decision	No	Pairwise comparison	Aggregate score of Y	Aggregate Score of N	Final decision
1	E1-E2	23	2	Y	51	E4-E7	5	20	N
2	E1-E3	7	18	N	52	E4-E8	17	8	Y
3	E1-E4	17	8	Y	53	E4-E9	19	6	Y
4	E1-E5	10	15	N	54	E4-E10	10	15	N
5	E1-E6	20	5	Y	55	E4-E11	16	9	Y
6	E1-E7	8	17	N	56	E4-E12	19	6	Y
7	E1-E8	17	8	Y	57	E4-E13	22	3	Y
8	E1-E9	15	10	Y	58	E4-E14	6	19	N
9	E1-E10	21	4	Y	59	E4-E15	9	16	N
10	E1-E11	23	2	Y	60	E4-E16	21	4	Y
11	E1-E12	15	10	Y	61	E5-E1	23	2	Y
12	E1-E13	19	6	Y	62	E5-E2	10	15	N
13	E1-E14	9	16	N	63	E5-E3	7	18	N
14	E1-E15	18	7	Y	64	E5-E4	12	13	N
15	E1-E16	17	8	Y	65	E5-E6	18	7	Y
16	E2-E2	10	15	N	66	E5-E7	10	15	N
17	E2-E3	9	16	N	67	E5-E8	11	14	N
18	E2-E4	11	14	N	68	E5-E9	8	17	N
19	E2-E5	7	18	N	69	E5-E10	17	8	Y
20	E2-E6	10	15	N	70	E5-E11	8	17	N
21	E2-E7	8	17	N	71	E5-E12	4	21	N
22	E2-E8	4	21	N	72	E5-E13	19	6	Y
23	E2-E9	11	14	N	73	E5-E14	3	22	N
24	E2-E10	9	16	N	74	E5-E15	21	4	Y
25	E2-E11	6	19	N	75	E5-E16	23	2	Y
26	E2-E12	15	10	Y	76	E6-E1	10	15	N
27	E2-E13	13	12	Y	77	E6-E2	11	14	N
28	E2-E14	8	17	N	78	E6-E3	7	18	N
29	E2-E15	8	17	N	79	E6-E4	9	16	N
30	E2-E16	16	9	Y	80	E6-E5	10	15	N
31	E3-E1	11	14	N	81	E6-E7	5	20	N
32	E3-E2	16	9	Y	82	E6-E8	18	7	Y
33	E3-E4	20	5	Y	83	E6-E9	7	18	N
34	E3-E5	11	14	N	84	E6-E10	22	3	Y
35	E3-E6	17	8	Y	85	E6-E11	5	20	N
36	E3-E7	7	18	N	86	E6-E12	4	21	N
37	E3-E8	14	11	Y	87	E6-E13	17	8	Y
38	E3-E9	15	10	Y	88	E6-E14	8	17	N
39	E3-E10	22	3	Y	89	E6-E15	16	9	Y
40	E3-E11	16	9	Y	90	E6-E16	18	7	Y
41	E3-E12	14	11	Y	91	E7-E1	7	18	N
42	E3-E13	19	6	Y	92	E7-E2	8	17	N
43	E3-E14	6	19	N	93	E7-E3	10	15	N
44	E3-E15	10	15	N	94	E7-E4	7	18	N
45	E3-E16	18	7	Y	95	E7-E5	5	20	N
46	E4-E1	4	21	N	96	E7-E6	9	16	N
47	E4-E2	16	9	Y	97	E7-E8	4	21	N

48	E4-E3	21	4	Y	98	E7-E9	10	15	N
49	E4-E5	11	14	N	99	E7-E10	8	17	N
50	E4-E6	9	16	N	100	E7-E11	11	14	N
No	**Pairwise comparison**	**Aggregate score of Y**	**Aggregate Score of N**	**Final decision**	**No**	**Pairwise comparison**	**Aggregate score of Y**	**Aggregate Score of N**	**Final decision**
101	E7-E12	6	19	N	152	E11-E2	8	17	N
102	E7-E13	15	10	Y	153	E11-E3	4	21	N
103	E7-E14	19	6	Y	154	E11-E4	9	16	N
104	E7-E15	7	18	N	155	E11-E5	11	14	N
105	E7-E16	20	5	Y	156	E11-E6	12	13	N
106	E8-E1	5	20	N	157	E11-E7	7	18	N
107	E8-E2	3	22	N	158	E11-E8	13	12	Y
108	E8-E3	7	18	N	159	E11-E9	11	14	N
109	E8-E4	11	14	N	160	E11-E10	15	10	Y
110	E8-E5	8	17	N	161	E11-E12	16	9	Y
111	E8-E6	10	15	N	162	E11-E13	20	5	Y
112	E8-E7	22	3	Y	163	E11-E14	21	4	Y
113	E8-E9	6	19	N	164	E11-E15	11	14	N
114	E8-E10	7	18	N	165	E11-E16	19	6	Y
115	E8-E11	16	9	Y	166	E12-E1	5	20	N
116	E8-E12	19	6	Y	167	E12-E2	7	18	N
117	E8-E13	13	12	Y	168	E12-E3	10	15	N
118	E8-E14	18	7	Y	169	E12-E4	11	14	N
119	E8-E15	8	17	N	170	E12-E5	4	21	N
120	E8-E16	19	6	Y	171	E12-E6	5	20	N
121	E9-E1	6	19	N	172	E12-E7	8	17	N
122	E9-E2	9	16	N	173	E12-E8	17	8	Y
123	E9-E3	4	21	N	174	E12-E9	11	14	N
124	E9-E4	8	17	N	175	E12-E10	9	16	N
125	E9-E5	11	14	N	176	E12-E11	9	16	N
126	E9-E6	11	14	N	177	E12-E13	18	7	Y
127	E9-E7	7	18	N	178	E12-E14	11	14	N
128	E9-E8	14	11	Y	179	E12-E15	8	17	N
129	E9-E10	10	15	N	180	E12-E16	18	7	Y
130	E9-E11	11	14	N	181	E13-E1	8	17	N
131	E9-E12	7	18	N	182	E13-E2	7	18	N
132	E9-E13	18	7	Y	183	E13-E3	5	20	N
133	E9-E14	8	17	N	184	E13-E4	10	15	N
134	E9-E15	9	16	N	185	E13-E5	8	17	N
135	E9-E16	18	7	Y	186	E13-E6	3	22	N
136	E10-E1	11	14	N	187	E13-E7	9	16	N
137	E10-E2	9	16	N	188	E13-E8	7	18	N
138	E10-E3	6	19	N	189	E13-E9	11	14	N
139	E10-E4	15	10	Y	190	E13-E10	10	15	N
140	E10-E5	5	20	N	191	E13-E11	7	18	N
141	E7-E8	4	21	N	192	E13-E13	4	21	N
142	E7-E9	10	15	N	193	E13-E14	2	23	N
143	E7-E10	8	17	N	194	E13-E15	6	19	N
144	E7-E11	11	14	N	195	E13-E16	13	12	Y
145	E10-E11	21	4	Y	196	E14-E1	5	20	N
146	E10-E12	14	11	Y	198	E14-E3	8	17	N
147	E10-E13	19	6	Y	199	E14-E4	3	22	N
148	E10-E14	20	5	Y	200	E14-E5	6	19	N

149	E10-E15	11	14	N	201	E14-E6	8	17	N
150	E10-E16	13	12	Y	202	E14-E7	10	15	N
151	E11-E1	5	20	N	203	E14-E8	12	13	N
No	**Pairwise comparison**	**Aggregate score of Y**	**Aggregate Score of N**	**Final decision**	**No**	**Pairwise comparison**	**Aggregate score of Y**	**Aggregate Score of N**	**Final decision**
204	E14-E9	5	20	N	223	E15-E13	14	11	Y
205	E14-E10	5	20	N	224	E15-E14	16	9	Y
206	E14-E11	8	17	N	225	E15-E16	20	5	Y
207	E14-E12	3	22	N	226	E16-E1	8	17	N
208	E14-E13	9	16	N	227	E16-E2	2	23	N
209	E14-E15	10	15	N	228	E16-E3	3	22	N
210	E14-E16	13	12	Y	229	E16-E4	2	23	N
211	E15-E1	4	21	N	230	E16-E5	5	20	N
212	E15-E2	7	18	N	231	E16-E6	3	22	N
213	E15-E3	5	20	N	232	E16-E7	6	19	N
214	E15-E4	1	24	N	233	E16-E8	1	24	N
215	E15-E5	2	23	N	234	E16-E9	5	20	N
216	E15-E6	1	24	N	235	E16-E10	3	22	N
217	E15-E7	15	10	Y	236	E16-E11	7	18	N
218	E15-E8	13	12	Y	237	E16-E12	3	22	N
219	E15-E9	13	12	Y	238	E16-E13	8	17	N
220	E15-E10	18	7	Y	239	E16-E14	2	23	N
221	E15-E11	3	22	N	240	E16-E15	14	11	Y
222	E15-E12	3	22	N					

Based on the analysis of MICMAC and the tier-up relationship among the factors, a 'House of Lean' (HoL) has been developed and presented in Figure 4 to ensure effective implementation of LPS in SMEs. Accordingly, the HoL has four components: Foundation, Pillar, Beam, and Roof. Vital Factors associated with each of these 4 components are as follows:
According to the MICMAC analysis and TISM framework, it is evident that the 4 vital factors: Financial capabilities, commitment and support from top management, effective leadership, and effective communication serve as significant vital factors at the bottom level of the hierarchy. These 4 factors exhibit high driving power and strongly influence other factors to enhance the process of implementing LPS in SMEs. They are considered the foundation of the HoL, providing a solid foundation for implementing LPS practices.

The middle level of the hierarchy consists of the 8 vital factors: Availability and allocation of resources, Training and education, lean consultant, shared improvement vision, Performance measurement and quick feedback response, Involvement of employees, Empowerment of employees, and Teamwork. These 8 vital factors possess moderate driving and dependent power, indicating their key role in supporting the top level of the factors. They are recognized as the pillars of HoL, supporting the top components of the HoL such as the beam and the roof.
At the topmost level of the hierarchy the 4 vital factors: organizational cultural change, understanding lean tools and techniques, skills and expertise, and continuous improvement are placed. These 4 vital factors are considered the beam of the HoL. They exhibit high dependent power but weak driving power. Finally, the roof represents all these 4 vital factors that contribute to the implementation of LPS in SMEs.

4. Conclusion

In this research, we aimed to develop a contextual relationship of a structural mode for implementation of LPS in Indian SMEs with House of Lean (HoL). This was achieved through three-phase approaches. During the first phase, a literature review was conducted to identify the factors of LPS in SMEs. Subsequently, a Pareto analysis was employed to determine the vital factors that are crucial for the effective implementation of LPS in SMEs. Based on this analysis, 16 vital factors were identified.

In the second phase, a conceptual framework using the Total Interpretive Structural Modeling (TISM) methodology, considering the 16 vital factors identified from the first phase of the research, were developed. This approach allowed

us to examine the relationship among the identified vital factors and provides practitioners with a clear picture and helps them develop strategies for the successful implementation of LPS in their working environment. Within this developed model, the vital factor: continuous improvement emerged as the first-level vital factor, while the vital factor: financial capabilities emerged as the last-level vital factor.

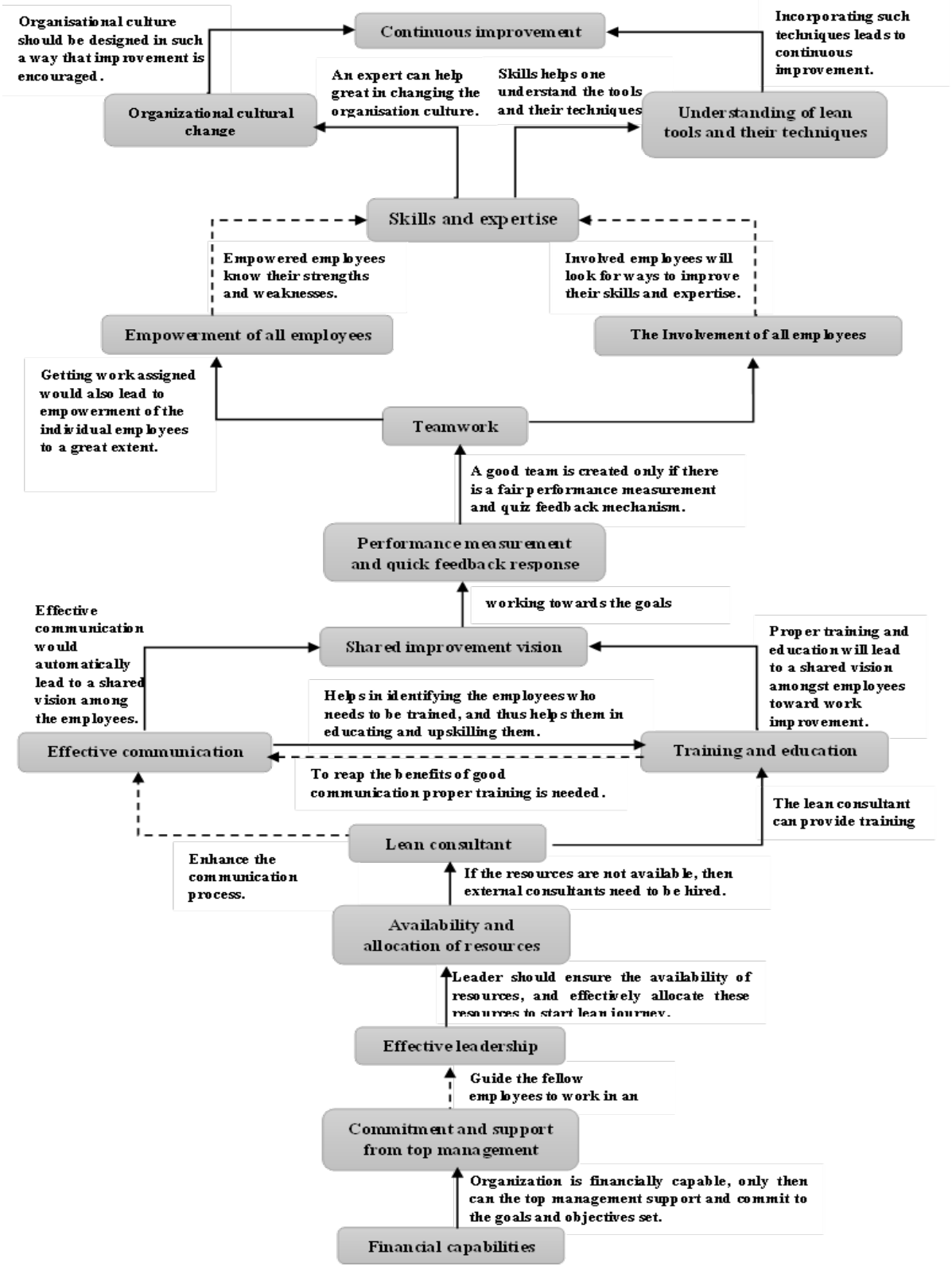

Figure 2. A Conceptual Framework for Implementation of LPS in SMEs

Finally, to analyse the driving power and dependence among the vital factors, we performed a cross-impact matrix multiplication applied to classification (MICMAC) analysis. This analysis helped us build a house of lean (HoL) factors, which provides valuable insights and guidance for organizations to practice lean principles in their businesses.

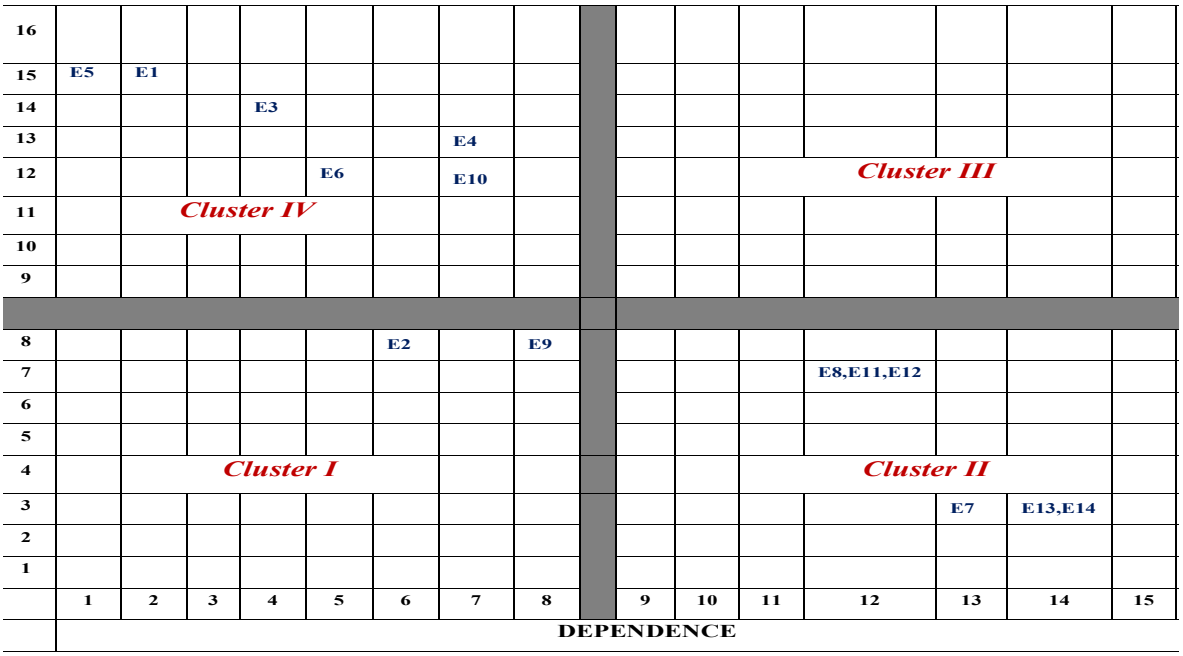

Figure 3. MICMAC Analysis on Vital Factors w.r.t. implementation of LPS in SMEs

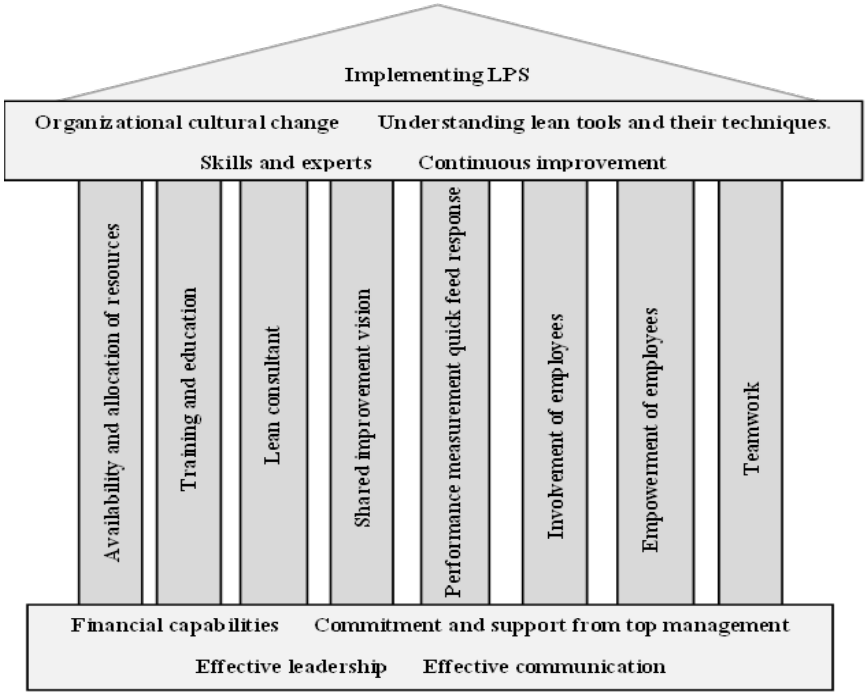

Figure 4. A House of Lean (HoL) for Implementing LPS in SMEs

Finally, based on the contextual relationship structural model and HoL developed in this research, SME managers can enhance their understanding of the lean vital factors and gain clarity on their relationships. This knowledge enables them to devise effective strategies for implementing the LPS in their manufacturing environment. Finally using the implemented LPS, SMEs are expected to eliminate all non-value-added activities in their production processes for improving system performance and increase overall efficiency.

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