DOI : https://doi.org/10.56452/7-12-49

ISSN: 0974-5823 Vol. 7 No. 12 December, 2022

International Journal of Mechanical Engineering

INTERACTIONS OF LEAN ENABLERS IN MANUFACTURING SMEs USING AN ANALYTICAL HIERARCHICAL PROCESS

Neha Gupta
Babu Banarasi Das Institute of Technology and Management, Lucknow, UP, 226013, India.
Email: er.mech.neha@gmail.com

Dr. Apurva Anand
Babu Banarasi Das University, Lucknow, U.P., 226013, India
Email: apurva2050@yahoo.co.in

Abstract: *Lean seeks to reduce waste and increase customer happiness. However, although initiatives within the industry are constantly changing and complicated, there are numerous questions that manufacturing practitioners may find difficult to manage, thus explaining precisely why the Lean methodology has not yet gained much traction in the sector. Furthermore, many find it especially harder to apply lean because industry businesses are project- based. Despite the recent surge in Lean manufacturing efforts, there are limitations with the implementation procedures. The management approach known as lean manufacturing (LM) is widely acknowledged for its ability to improve organizational performance by enhancing processes for production while minimizing waste, both in time and effort. Lean programming continues to be used by a large number of SMEs worldwide to thrive in the current competitive climate. Lean is an effective management strategy that is supported by several vital enablers. To create a competitive edge, lean leader's primary responsibility is to understand the interrelationships among these facilitators. This study uses the Hierarchy Analytic Method Algorithm to examine the contextual relationships between lean enablers in SMEs in Uttar Pradesh. The twenty- six LMEs are chosen and reorganized from the several LMEs shortly after implementation account multiple. LM practices through the literature review and from numerous scholars and recognized SMEs to develop the AHP model for Uttar Pradesh SMEs. The study continues with a lean enabler algorithm, the Analytical Hierarchical Process (AHP) Algorithm, which is intended to assist small and medium-sized enterprise business practices.*

Keywords: *Lean Manufacturing (LM); Lean Manufacturing Enablers (LMEs); Analytical Hierarchical Process (AHP); Small and Medium- sized Enterprises (SMEs); Uttar Pradesh (UP).*

1. INTRODUCTION

"A methodical strategy for waste detection and elimination through ongoing improvement aimed at encouraging the consumer's push in the quest for excellence" is how Lean Manufacturing (LM) is defined [1]. All errors and shortcomings that lower client satisfaction are referred to as "waste". To optimize value and reduce defects, an expertly conducted implementation of lean helps accelerate constantly improving culture. However implementing the strategy in any kind of business is not straightforward, and it's not straightforward to preserve its momentum either. The minimalist approach regarding thinking that is powered by several interconnected enablers that require complete support from various organizational stakeholders.

This study's main goal is to rank and identify lean enablers to create an analytical blueprint for a long- term lean approach in UP- SME producing. (1) Understanding lean essential enablers in SMEs is the primary goal. (2) Examine how these facilitators relate to one another in context. (3) Using the Analytical Hierarchical Process (AHP), create an analytical model for lean adoption. (4) Use MICMAC (cross- impact matrix multiplication utilized for classification) analysis to rank the identified lean enablers. By determining the contextual relationships between lean enablers in SMEs, this study will add to the corpus of knowledge. It also helps the workforce in SMEs identify the people who make lean organizations work.

In the current era of globalization, small and medium- sized enterprises (SMEs) must possess the ability to preserve, cultivate, arrange, and leverage their workforce's lean manufacturing expertise to continue to thrive. Lean methods are thought to be a crucial and essential component of competitive expansion. For all SMEs in Uttar Pradesh, adopting lean manufacturing is an essential decision. This choice could determine the SMEs success or failure, so it's critical to carefully weigh all the pros and drawbacks of implementing lean manufacturing prior to reaching a final decision. Ensuring that the decision produces all anticipated benefits is crucial.

The US industry is facing significant problems as a result of the recent upheaval in both the services and manufacturing industries. The traditional managerial style is no longer a suitable means of addressing the issues presented by the focused on customers and intensely aggressive market. The aforementioned variables make it very challenging for firms to find fresh strategies to keep climbing their organizational ladder in a competitive, a global marketplace that is steadily expanding. Whereas certain organizations benefit greatly through financial security, others suffer from a lack of awareness of how consumer behavior and cost structures are changing. Many manufacturing companies have started to use lean manufacturing techniques to improve their businesses performance in an attempt to escape this predicament and increase profitability.

The three main tenets of the lean manufacturing system- waste elimination, cost reduction, and employee empowerment- have been used for many years in Japan. The corporate mentality that has long been established in the US is completely different than that of Japan. In the west, it was conventional wisdom that adding money to the production expenses to determine what was wanted selling price was the only method available to turn a profit. Conversely, the Japanese methodology posits that the selling price is determined by the customers themselves. Customers are willing to pay a higher price for products and services that are higher in quality. The profit is calculated as the difference among the price reflects the expenditure of the product. Lean manufacturing aims to achieve approach that's to minimize costs through the elimination of waste from each element of the value stream. Make money, increase sales, and maintain your competitiveness in an industry that is expanding globally. The definition of a value stream is "the specific activities throughout a supply chain necessary to conceptualize, order, and distribute a particular well or value". According to Womack and his colleagues, a "lean" system uses fewer inputs overall to produce the same results as a traditional mass production system but yet provides the user with more options. There are numerous titles for the business philosophy. The terms dynamic manufacturing, immediate manufacturing, synchronous manufacturing, and world-class manufacturing, along with continuous flow, are occasionally employed when associated with lean manufacturing. Thus, the core idea behind lean manufacturing is cost reduction through ongoing improvement, which will eventually end up resulting in lower costs for goods and services and more profits. "Lean" emphasizes eliminating or cutting down on wastes (or "muda", the Japanese word for waste), as well as optimizing or making full use of operations which deliver value from the viewpoint of the customer. When looking at a product or service from the consumer's point of view, value is equal to whatever the client is prepared to pay for. Thus, the foundational idea of lean manufacturing is the removal of waste. For industrial firms, any of the following entities could be involved in this-

- **Material-** Produce final goods from all raw materials. Steer clear of surplus raw materials including scrap.
- **Inventory-** Don't have any unused material and maintains a steady flow to the consumer.
- **Overproduction-** Make precisely the right quantities of stuff at the right time for your customers.
- **Labor-** Stop anyone people moving around without permission.
- **Complexity-** Attempt to find simpler solutions to issues rather than more involved ones. In general, such as complex solutions are more challenging for individuals to administer and generate more waste.
- **Energy-** Make the most efficient use of people and equipment. Steer clear of inefficient processes and excessive electricity use.
- **Space-** To create greater effectiveness in the utilization of space rearranges personnel, tools, and workstations.
- **Defects-** Try you're hardest to get elimination of defects.
- Transportation- Minimize the need to transmit information and resources that don't improve the finished product.
- **Time-** Steer clears of drawn-out preparations, hold- ups, and unforeseen machine outages.
- **Superfluous Motion-** Remain clear of extreme bending, stretching, and losing things frequently.

Because waste streams are interconnected, eliminating one might result in the decrease or removal of other waste sources. Inventory is arguably the biggest source of waste. Finished parts and work- in- process inventories should be decreased or removed due to the fact that they provide no value to the final product. Inventory reduction can reveal hidden issues so that quick action can be undertaken. Limiting the amount that can be produced of production lots is one of the numerous strategies to cut inventory. To maintain a constant cost per unit, as stipulated by the well- known economic order quantity formula, lot sizes should be reduced in tandem increasing setup times.

Shingo created the single minute exchange of dies (SMED) concept at Toyota to cut down on setup times. For example, setup periods for huge punch presses might be shortened from hours to less than 10 minutes. This has a significant impact on lot size reduction. Making a conscious decision to limit machine downtime is another strategy for lowering inventory. Preventive maintenance is one way to achieve this. It is evident that lowering inventory additionally minimizes other sources of waste. For instance, space that was once utilized for inventory storage could be put to better use by expanding the facility's capacity.

Additionally, cutting preparation times as a way to cut inventory at the same time reduces wasteful waiting times.

Time spent traveling is another wasteful activity. The product does not gain value by having parts moved from the one side of the premises to the other. Reduced transit times during the manufacturing process are therefore crucial. Using a cellular manufacturing plan to guarantee uninterrupted supply of the product is one considering doing this? This also aids in the elimination of energy waste, another cause of waste. Unproductive processes can be reduced when people and machines are organized into cells. This is since a group of individuals can devote all of their time to a single cell, preventing overuse of human resources. Without a doubt, removing waste is an essential component of surviving in the modern manufacturing environment. Businesses should aim to provide reasonably priced, high- quality goods that can be delivered to clients as quickly as feasible. To eliminate or at least limit the causes of waste, there are a variety of tools that

DOI : https://doi.org/10.56452/7-12-49

they were developed at Toyota. Lean manufacturing relies heavily on a number of different lean manufacturing enablers (LMEs) [41, 43].

Though they don't fully execute lean manufacturing (LM), SMEs are aware of the significance of all the lean manufacturing enablers (LMEs). The industrial structure, business strategy, and knowledgeable team are the factors that were successfully put into practice. The success of LM projects can be influenced by a wide range of LMEs, encompassing organizational changes, technology, culture, leadership, and employee motivation.

2. LITERATURE REVIEW

2.1 Lean Manufacturing (LM) - The lean methodology was first presented as an adaptation of the Toyota Production System (TPS). Nonetheless, both industrialized and developing nations have expanded the degree of its adoption throughout the last three decades [2]. Through the improvement of value-added activities, Lean Manufacturing (LM) is a collaborative production method that aims to manufacture products as effectively and inexpensively as possible while utilizing less labor, time, space, and inventory. It is described provides a model that improves the production line built reducing inefficiency, emphasizing perfection, and raising worker productivity [3].

The bulk of businesses have had difficulties, and a large number of their attempts did not succeed to integrate lean programming, despite the widespread acceptance, efficacy, and many different LM adoption attempts [4]. According to Bhasin and Burcher [5], only 10% of firms have successfully implemented lean management (LM), and even fewer have succeeded in doing so to a satisfactory degree. Balles [6] linked the majority several shortcomings associated with a misinterpretation of lean management (LM), top managers are unable to provide sufficient consideration to the cognitive aspects or behavioral modifications of LM. Researchers have proposed a list of essential enablers to help organizations embrace lean management (LM). These enablers should help to smooth the lean transition and prevent expensive errors or failures. An in- depth knowledge of these facilitators and their interrelationships might assist the organization in identifying its requirements and level of readiness for LM implementation. Visual management, a thorough grasp of lean principles [2], financial capability and knowledge, quality enhancement and housekeeping, internal competency, and an evaluation system [7], integrating cultural shifts and incentive systems [8], and collaboration [9] are the lean enablers that have received the greatest attention in the literature.

2.2 Lean Adoption in SMEs - SMEs are crucial to the global economy's ability to create value. They are referred to as the employment, competitiveness, and innovation dynamics. They contribute to over 60% of job possibilities and makeup over 95% of the industrial sector globally [10]. To be competitive, LM is something that many businesses try to apply. However, the literature hasn't done a good job of covering all the components of lean enablers in SMEs, particularly in Middle Eastern nations like Iraq's Kurdistan area. This is a result of the difficulties SMEs frequently face when implementing lean. Before anything else, the right adoption is the one that allows the business to attain its goals. Since SMEs are unable to replicate the strategies used by major corporations, they are in need of a more appropriate, doable, and compact roadmap for utilizing LM. According to Bhasin [11], external LM practices- like supplier and customer management- are less appropriate to SMEs than internal ones- like management time, machinery, and human resources. According to Prajogo and Johnston [12], it is crucial to combine internal and external enablers to get started with the lean adoption process. Thus, identifying and prioritizing lean enablers is essential for efficient lean adoption in SMEs.

Major drivers of lean techniques in SMEs were identified by Achanga et al. [9] such as civilization, effectiveness, and lead time, the delivery process, financing, and administration. They believe that implementing lean methods in certain domains is going to improve the quality, sales, revenue, and productivity of the company. Additional enablers like kanban, supplier responsibility, graphical leadership, 5S, line balance, standard procedures, poka- yoke, complete preventative upkeep, and Kaizen were suggested by Laoha and Sukto [13]. Table 1 lists sixteen factors that facilitate the successful adoption of LM. Table 1 shows that researchers consider the most prevalent enabler for LM implementation to be top management commitment, while the least common enablers are quality raw materials or defect reduction.

2.3 Development of Analytical Hierarchical Process (AHP) - AHP is a reputable method for making decisions. As a result, AHP may support the decision- making process for Uttar Pradesh SMEs identification of LMEs enabling the successful adoption of lean manufacturing. Complex multi- person, multi- attribute, multi- period problems can be hierarchically structured using the AHP approach. A scale that shows how much a particular component dominates another in relation a more complicated component could exist used to generate pair- wise assessments of the element (typically, alternatives and characteristics). Priority weights can then be derived from this scaling procedure [16, 18, 36].

The primary goal is to use AHP to establish pair wise comparisons of the feature (typically, alternatives and qualities) in order to develop the links among the discovered enablers. These comparisons can then be translated towards priority weights, or scores. These LMEs are theoretically developed through expert discussion and a variety of literature sources. Some LMEs have been taken from the work of those who have studied lean manufacturing more broadly or have delved into great detail on a specific enabler. These LMEs can be portrayed by generic themes, despite considering that different scholars have identified those using different terminologies. Additionally, they have received varying degrees of attention and visibility in the literature when they have been discussed.

Saaty created the decision- aiding technique known as AHP in 1970. It assists in choosing the best options to meet all of the requirements in a multi- attribute decision-making situation. Based on the decision- maker's judgment, the AHP process quantifies the corresponding responsibilities in a particular collection numerous options from each proportional magnitude. It emphasizes the significance amongst the individuals who make decisions intuitive judgments, additionally emphasizes the consistency of the assessment of alternatives in the decision- making process. This approach's strength is in its capacity to organize complicated problems involving several people, attributes, and periods in a hierarchical manner. The AHP methodology has been implemented by various researchers in an extensive variety of subjects, with published results in the literature. When it has to do with organizing and evaluating intricate multi-attribute decision problems, the AHP offers remarkable performance as well as adaptability.

Table 1 AHP as reported in Literature

Details	Author
Using AHP to act as a strategic selection tool to support choices of machine tools.	Ref. [11]
Using a fuzzy AHP approach in Taiwan stone industry.	Ref. [32]
Using AHP-QFD for semiconductor industry in Taiwan.	Ref. [21]
Application of AHP for lean implementation analysis in 6 MSMEs.	Ref. [16]
AHP-based lean concept selection in a manufacturing organization.	Ref. [96]
Measuring the status of lean manufacturing using AHP.	Ref. [13]
Barriers and strategies for sustainable manufacturing implementation in SMEs: A hybrid fuzzy AHP-TOPSIS framework.	Ref. [18]
An AHP Model of World Class Manufacturing Enablers for Indian Manufacturing Organizations.	Ref. [28]
Criteria in AHP: a Systematic Review of Literature.	Ref. [17]
Implementation of lean manufacturing in SMEs using fuzzy analytical hierarchy process.	Ref. [29]
Analytical Hierarchy Process (AHP) In Manufacturing And Non-Manufacturing Industries: A Systematic Literature Review.	Ref. [30]

There could be a multitude of facilitators impacting the application of lean manufacturing. Nevertheless, the situation is significantly better conveyed by the both direct and indirect connections between the facilitators than by the individual components considered separately. As consequently, AHP creates insights into whether these linkages are understood collectively.

2.4 The Process of Analytic Hierarchy Process - The four steps of the AHP process include an optional fourth stage that can be completed concurrently [40, 42].

Step 1: Assessing each lean manufacturing enabler's (LMEs) relative worth by utilizing survey data and a variety of literature sources.
Step 2: Using the recommended numbers, a matrix of paired comparisons will be generated for lean manufacturing enablers (LMEs) to indicate the relative preferences of two LMEs.
Step 3: A normalized matrix representing the results of the paired comparisons and priority weight calculations has been generated.
Step 4: To evaluate the prediction weight, a list of all the combinations of comparisons together with the priority ranking that results from various scenarios for each characteristic are created.

3. METHODOLOGY

Thomas L. Saaty established the Analytic Hierarchy Process, a structured decision- making process, in the 1970s. AHP is intended to support individuals or groups in making decisions when confronted with intricate issues including a variety of criteria and options. It is extensively utilized in many different domains, including as social sciences, industries, engineering, environmental management, and healthcare.

AHP provides a systematic and structured approach to decision- making, allowing decision- makers to make more informed and rational choices, especially when dealing with complex, multi- criteria problems. It helps in clarifying preferences, managing subjective judgments, and facilitating group decision-making processes. AHP is a valuable tool for prioritization, resource allocation, project selection, and other decision- related tasks [21].

3.1 Steps in an Analytic Hierarchy Process - The Analytic Hierarchy Process (AHP) is a structured decision-making methodology that involves several steps to help prioritize and make choices among alternatives based on a set of criteria. Here are the key steps in the AHP-

- **Problem Definition**- Clearly defines the decision problem and establishes the objective of the decision- making process. Determine the criteria that will be used to evaluate alternatives and the set of alternatives under consideration.

- **Hierarchical Structure**- Make a structure that is hierarchical, that breaks breaking the choice challenge further into a hierarchy of criteria and sub- criteria. The hierarchy typically consists of three levels: the goal, criteria, and alternatives.
- **Pair wise Comparisons**- Pair wise comparisons should be done for all levels of the hierarchy (criteria, sub-criteria, and alternatives) to ascertain the significance or preference of each element. Use a scale of 1 to 9, where 1 represents equal importance, 3 represents moderate importance, and 9 represents extreme importance. These comparisons are usually done using a matrix format.
- **Create Comparison Matrices**- Construct comparison matrices based on the results of the pair wise comparisons. Each matrix represents a level of the hierarchy. The elements of the matrix contain the ratio of the importance values assigned during the comparisons.
- **Consistency Check**- To make sure the pair wise comparisons are acceptable and consistent does consistency checks. To evaluate the consistency of the comparisons, the consistency ratio (CR) is computed. It might become necessary to implement improvements to the comparisons if CR rises throughout a predetermined level (e.g., 0.10).
- **Calculate Weight Vectors**- Use mathematical methods, such as the Eigen value method, to calculate the weight vectors for each level of the hierarchy. These weight vectors represent the relative importance or priority of the criteria, sub- criteria, and alternatives.
- **Aggregate Scores**- Aggregate the scores of the alternatives by multiplying the weights of the criteria and sub- criteria with the performance values of the alternatives. This step produces an overall score for each alternative.
- **Sensitivity Analysis**- Conduct sensitivity analysis to assess the robustness of the results. Evaluate how changes in the weights of criteria affect the rankings and make adjustments if necessary.
- **Rank Alternatives**- Rank the alternatives based on their overall scores. The alternative with the highest score is considered the most preferred or recommended choice.
- **Decision and Interpretation**- Use the ranked list of alternatives to make the final decision. Interpret the results and consider the implications for the decision problem.
- **Documentation**- Document the entire AHP process, including the hierarchy, pair wise comparisons, calculation of weights, and final rankings. This documentation ensures transparency and reproducibility of the decision-making process.
- **Implementation**- Implement the chosen alternative or course of action based on the AHP results. Monitor the outcomes and assess whether the decision leads to the desired results.

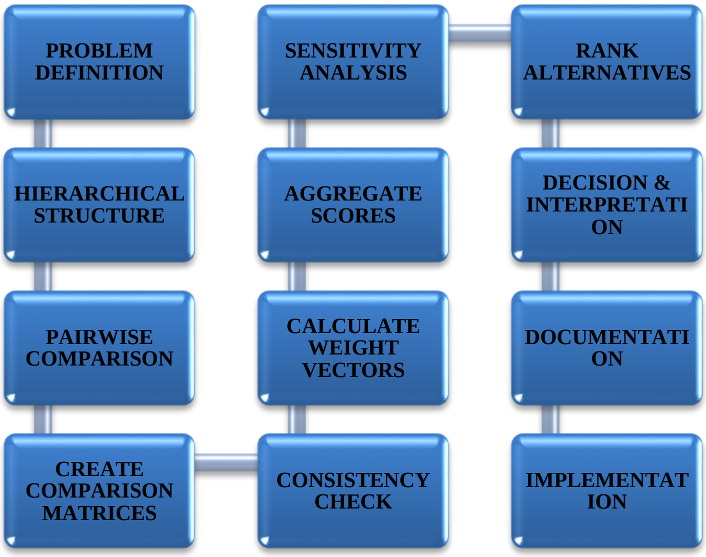

Figure 1 Step in Analytic Hierarchy Process

3.2 Flow Diagram for Preparing an Analytic Hierarchy Process - Creating a flow diagram for preparing an Analytic Hierarchy Process (AHP) can help visualize the steps involved in this decision- making methodology. Here's in Figure 2 a simplified flow diagram to guide you through the process of preparing AHP-

DOI : https://doi.org/10.56452/7-12-49

Figure 2 Flow Diagram for preparing an Analytic Hierarchy Process

This flow diagram provides a visual representation of the sequential flow of steps in preparing and executing an AHP analysis. It helps guide you through the process, from defining the problem to making a final decision based on the AHP results. Remember that AHP can be a flexible tool and can be adapted to various decision- making scenarios. Each step leads to the next, ultimately culminating in the final decision and implementation of the chosen alternative [17, 21, 23, 27, 31]. Initiation/ institutional, acceptance, reutilization, and infusion are the methods used to construct this model. Every module has its own determinants, or elements, that must exist in order for the specific implementation phase to occur successfully. This study's AHP methodology is modified [31, 38, 40].

According to this approach, every module operates independently of the others. Following the identification of the variables linked to each module from the literature, pair wise comparisons of the LMEs can be conducted using a scale reflecting the extent to which one LME predominates over another concerning a higher- level element. The model mentioned earlier measures the degree of preference on a range of 1 to 5 while selecting each pair wise comparison. Then, utilizing this scaling process, weights of priority for substitute assessment. Table 2 illustrates the explicit grades of preference amongst the two LMEs, a and b, that were employed in the model.

Table 2 Preference Degree between Two Lean Manufacturing Enablers (LMEs)

If a is ……..as (than b)	Preference number to be assigned is
Equally Important	1
Weakly more Important	2
Strongly more Important	3
Very Strongly more Important	4
Absolutely more Important	5

The resulting preference numbers are then used to generate a comparison matrix for all LMEs. For inverse comparisons like b-a, for a-b, the preferable number's reciprocal is applied. Based on LMEs the facts that have been ordered according to their relative relevance, the priority weight will be calculated. The appropriate LMEs to each of the module's determinants, as available or practiced in their SMEs, are capable of being evaluated by Lean Manufacturing implementation SMEs [28, 34, 35].

Based on the responses, the comparison matrix for the assessment will also be created. The order of the evaluation level and the order of level, which is based on the user's assessment of the effectiveness of the LMEs used or accessible in SMEs is multiplied to determine the prediction weight. Prediction = $\sum X_i Y_i$, where Xi is the priority weight and Yi is the evaluation rating for element i, indicates the industry's level of preparation or sufficiency with regard to particular LMEs. The decision- maker can forecast the results of implementation for each module by using the comparison weight that AHP will produce. When the projected strength is 0.5, it means that each module has an equal chance of succeeding and failing [18, 26, 34, 41].

4. LEAN MANUFACTURING ENABLERS (LMEs)

One study indicates that, when it comes to LMEs dealing with strategy and leadership, the most crucial element is top management support, when it pertains to LMEs dealing with industrial culture, the creation of a culture of sharing and atmosphere is crucial but requires support from informational technology, when it comes to LMEs interacting with people, training courses and learning channels, employee incentive programs are one of the most significant variables that must be implemented and when it arrives to LMEs dealing with informational technology, the ability to quickly search information for its re- use is becoming increasingly crucial, away from the digitization of documents. Nineteen LMEs and nine LMEs have been proposed in two more studies, the most significant LMEs are top management commitment. Another study suggests the LMEs for LM adoption, which involves top managerial assistance and an environment that values learning, technological infrastructure, distinct objective and language, relationship to economic success, and shift in motivational approaches with lean, based on lessons collected from leading industries.

The main findings of this research are a ranked list of LMEs for implementation LM in Uttar Pradesh SMEs, arranged in order of importance. The twenty- six LMEs are selected and regrouped from the various LMEs after considered several LM practices through the literature review and from various scholars and well known SMEs to develop the AHP model for Uttar Pradesh SMEs. Twenty- six enablers for a successful Lean implementation have been determined in the present study. The enablers identified specifically for Lean implementation are shown in Table 2, along with pertinent sources for each enabler, under seven factor groups.

Table 3 Enablers with Description for Lean Implementation under Category

Category	Code	Enablers	Description
Financial	FIE 1	**Existence of a clear marketing strategy** [21][23][25][29]	Lean Implementation is strengthened by an innovative marketing strategy.
	FIE 2	**Long term profit of implementing Lean tools** [23][24][27]	Long- term financial gain for businesses results from the implementation of lean tools.
	FIE 3	**Willingness to invest in Lean practices** [21][29]	Purchasing Lean methods and tools making it easier for individuals to put Lean into practice.
	FIE 4	**Market share** [21][23][29]	Gaining market share and expanding the company's operations contribute to more effective Lean implementation.
Managerial	MAE 1	**Management commitment** [22][29]	Lean deployment can be made easier by middle and upper-management commitment to lean principles.
	MAE 2	**Incentive mechanisms** [22][26][29]	An incentive system increases process efficiency and functions as a motivator for lean implementation.
	MAE 3	**Creating awareness for Lean** [14][22][29]	Increasing Lean awareness brings about a cooperative and productive framework for Lean implementation procedures.
	MAE 4	**Customer satisfaction** [21][23][24][34]	Implementing Lean with consumer fulfillment as the business policy guarantees its success.
Technical	TEE 1	**Lean training** [23][27][28]	A more defined methodology for the Lean implementation process, leading to the intended success, has been generated by lean training.
	TEE 2	**Availability of Lean tools and techniques** [23][28][29]	Lean deployment is facilitated by the readily accessible of Lean resources and knowledge of Lean techniques.

	TEE 3	**Clear understanding of technical requirements in Lean practices** [28][34]	In order Lean implementation to be successful, definitions of terms and best practices require being understood clearly.
	TEE 4	**Effectiveness of Value Stream Mapping** [21][29][34]	Value Stream Mapping provides a graphical depiction of the processes to be accomplished and aids in visualizing the Lean implementation process.
Workforce	WOE 1	**Supportive environment for workforce efficiency** [13][21][27][32]	Efficiency of the workforce minimizes waste in lean processes, and this leads to successful lean deployment.
	WOE 2	**Existence of certified and qualified Lean personnel** [14][21][23][29]	Employees with lean certification are better equipped with developing implementation strategies since they are familiar with the terminology.
	WOE 3	**Efficiency of human resource management activities** [4][21][29]	Effective human resource management strategies, such as identifying the most qualified employees for the projects, complement lean principles while also having a favorable impact on lean adoption.
	WOE 4	**Availability of consulting team members in Lean** [13][21][22]	For the Lean implementation to be successful in resolving conflicts in processes, Lean consulting and establishing a team of consultants available are important.
Culture	CUE 1	**Adopting a Lean culture** [13][29]	Embracing a lean culture makes it less difficult for workers to understand what significance lean techniques are and how they could contribute to safer workplace procedures.
	CUE 2	**Lean as a firm strategy** [21][29]	By integrating Lean into company culture, employees become more familiar with the techniques and their implementation process takes a shorter period when implementing Lean.
	CUE 3	**Lean leadership** [4][22][29]	Ensuring excellent operations in Lean adoption is ensured by having an abundance of Lean leaders and managers to support Lean activities.
	CUE 4	**Employee moral** [29][32]	Lean methods operate more efficiently whenever employee morale is high.
Government	GOE 1	**Supportive nature of governmental regulations in Lean** [23][24]	The effectiveness of lean methods and their implementation are dependent upon government support, such as the introduction of rules that facilitate the adoption of lean procedures.
	GOE 2	**Government incentives** [13][23]	Government incentives, like as tax breaks as well as reward systems, enhance the possibility that leaner practices will result in a successful lean implementation.
	GOE 3	**Availability of resources for Lean** [23][29]	Enhancing the performance of Lean initiatives is possible through the offering of Lean resources by government entities, such as government-funded Lean groups and projects.
Communication	COE 1	**Existence of clear roles in Lean** [13][21][29]	Determining responsibilities in Lean operations minimizes conflicts of interest and enhances productivity.
	COE 2	**Existence of Lean research groups and initiatives** [34] [35]	Lean research teams and projects have an opportunity to impact lean initiatives that end up resulting in successful lean deployment.
	COE 3	**Existence of communicating Lean practices** [13][23][28]	In order to share best practices for implementing Lean, it is imperative that the expertise of these techniques be widely disseminated throughout various groups.

Table 4 Lean Management Enablers

Sr. No.	LMEs	Ref. [4]	Ref. [9]	Ref. [13]	Ref. [14]	Ref. [21]	Ref. [22]	Ref. [23]	Ref. [24]	Ref. [25]	Ref. [26]	Ref. [27]	Ref. [28]	Ref. [29]	Ref. [32]	Ref. [34]	Ref. [35]
1	FIE 1					√		√		√				√			
2	FIE 2							√	√			√					
3	FIE 3					√								√			
4	FIE 4					√		√						√			
5	MAE 1						√							√			
6	MAE 2						√				√			√			
7	MAE 3				√		√							√			
8	MAE 4					√		√	√							√	
9	TEE 1							√				√	√				
10	TEE 2							√					√	√			
11	TEE 3												√			√	
12	TEE 4					√								√		√	
13	WOE 1			√		√						√			√		
14	WOE 2				√	√		√						√			
15	WOE 3	√				√								√			
16	WOE 4			√		√	√										
17	CUE 1			√										√			
18	CUE 2					√								√			
19	CUE 3	√					√							√			
20	CUE 4													√	√		
21	GOE 1							√	√								
22	GOE 2			√				√									
23	GOE 3							√						√			
24	COE 1			√		√								√			
25	COE 2															√	√
26	COE 3			√				√					√				

The predictive model proposed in this study based on the Analytical Hierarchical Process (AHP) which can help SMEs in LM implementation. The vital variables affecting LM implementation are included into the model for helping managers to analyze and gauge the SMEs capability in LM implementation. It also helps in identifying the corrective actions essential to ensure successful LM implementation. The model can also be used as a check method or as a guide for assisting users understand what modifications are required and to what extent. By accounting for all (main) LMEs, this model can help improve the decision-making process associated with LM adoption [40, 41].

DOI : https://doi.org/10.56452/7-12-49

5. APPLICATION OF ANALYTICAL HIERARCHICAL PROCESS

The success or failure of the lean manufacturing implementation initiation modules is determined using the AHP approach, as demonstrated. Every module undergoes the same process, and it can be utilized to determine the prediction frequency for every module. The potential implementation result and the properties of the hierarchically organized initiation module are depicted in Figure 3.

This constitutes a three level hierarchy i.e. priority weights of attributes, priority weights for alternatives with respect to attributes and priority weights for prediction which are explained further [15, 26, 28, 35].

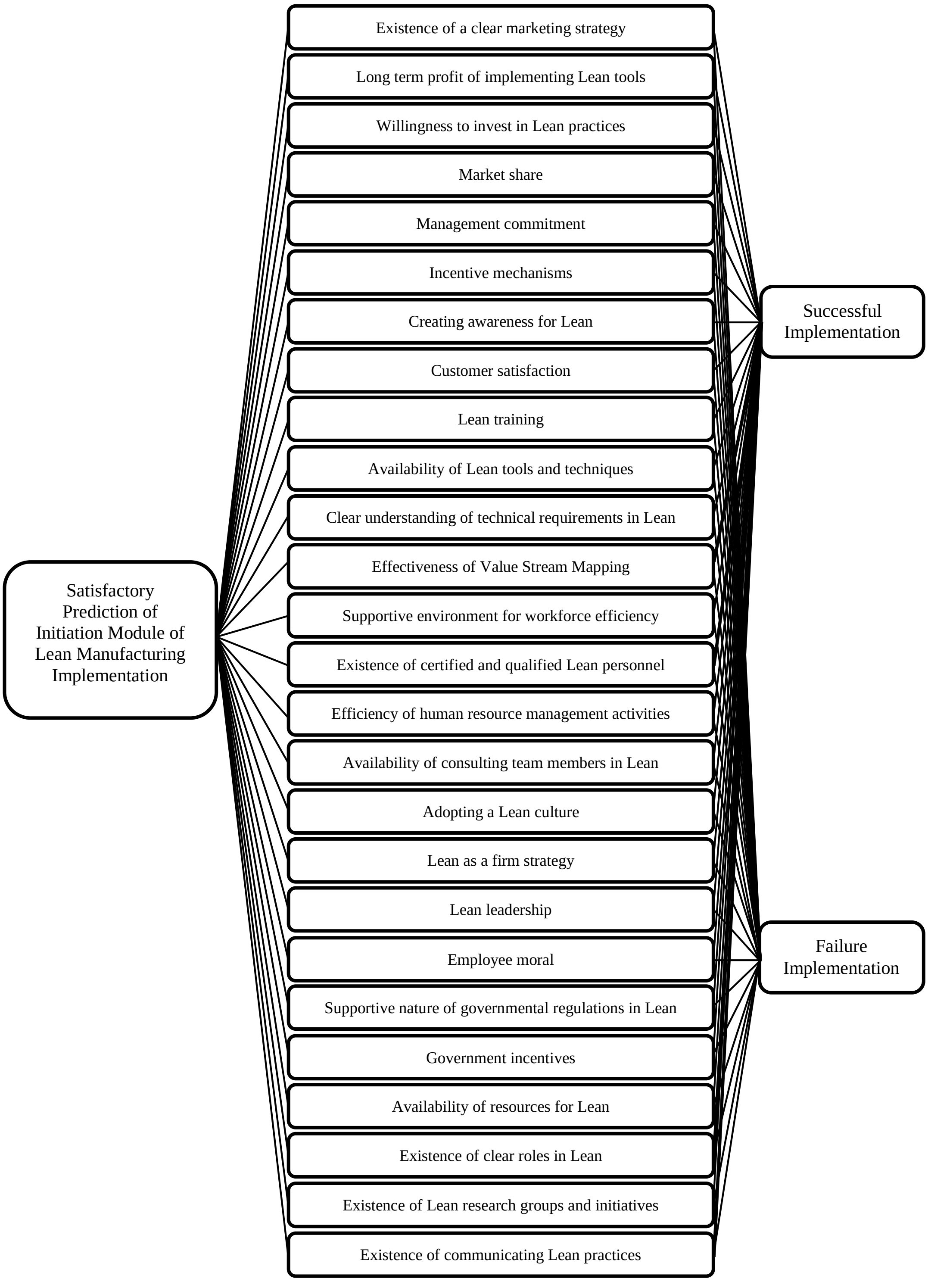

Figure 3 Hierarchy diagram on Initiation Module of LM Implementation

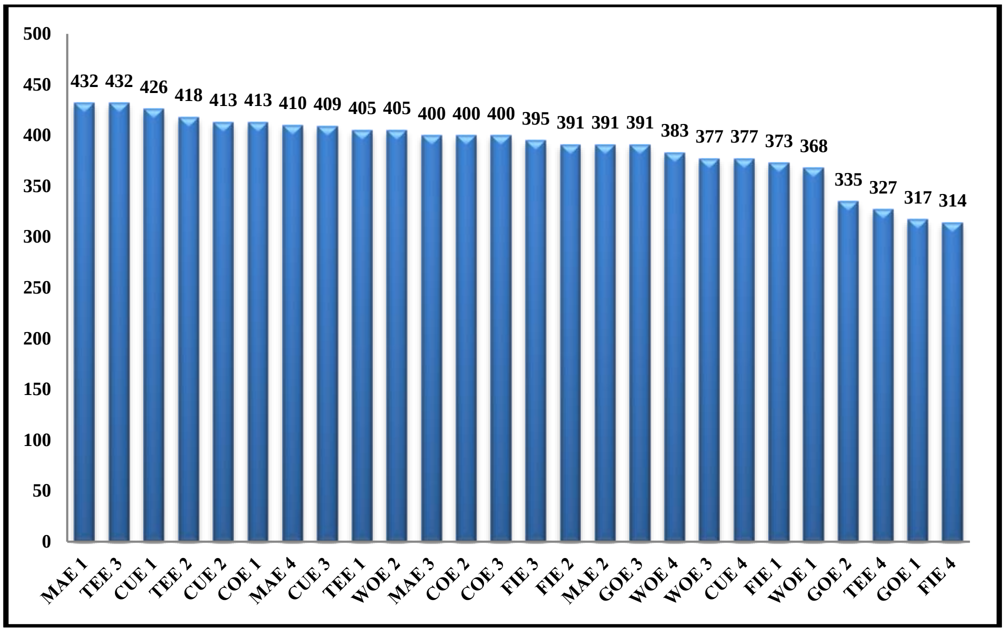

Figure 4 Enablers of Lean Implementation

5.1 Priority Weights of Attributes -

Table 5 Matrix of Pair Wise Comparison for Lean Manufacturing Enablers

LMEs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	1	1	1	2	1/3	2	1	2	1/2	1	1	1	1	2	2	2	1	2	1	1/2	3	2	2	1/2	1	1
2	1	1	1	1/2	3	1	1/2	3	1	1	1	2	1	1/2	1	1	2	1	1/2	3	1	1	1/2	1/3	2	2
3	1	1	1	1/2	1	2	1	2	1	1/2	1/2	1	1	1	1	1/2	1	1/2	1/3	1	1	2	1	1	1	1
4	1/2	2	2	1	1	1	2	1	1	1	1	1/2	3	1	2	1	2	1	1	1/2	1	1/3	1	1	2	1/2
5	3	1/3	1	1	1	4	1	1	1/2	1	2	2	1	3	1/2	1	2	1	1/5	1	2	1	1	1/3	1	1
6	1/2	1	1/2	1	1/4	1	2	1	1	2	1	1	1/2	1	1	2	1	1/3	1	1	1	1	1	1	1/2	1
7	1	2	1	1/2	1	1/2	1	1	2	1	1	1	1/2	1	1/2	1	1/2	2	3	1	1/2	1	2	1	1	4
8	1/2	1/3	1/2	1	1	1	1	1	1/3	1/2	1	2	1	2	1	1/2	1	4	1	1	1	1	2	1	3	1
9	2	1	1	1	2	1	1/2	3	1	1	1/3	1	1	1	1	1	1	1	1/2	1/3	1	1/2	1	1/2	1	1/2
10	1	1	2	1	1	1/2	1	2	1	1	2	1	2	1	1	2	1/2	2	1	1	1	3	1/2	1	1	1
11	1	1	2	1	1/2	1	1	1	3	1/2	1	1/2	1	2	1	1/3	1	1	3	2	1	1	1	2	1	1
12	1	1/2	1	2	1/2	1	1	1/2	1	1	2	1	1	1	1	1	2	1	1	1	1/2	2	1	1	2	1
13	1	1	1	1/3	1	2	2	1	1	1/2	1	1	1	1/2	1	1	1	1/2	1	2	1	1	1/3	1	1/2	2
14	1/2	2	1	1	1/3	1	1	1/2	1	1	1/2	1	2	1	1/2	1	1/3	1	2	1	2	1	1	2	1	1
15	1/2	1	1	1/2	2	1	2	1	1	1	1	1	1	2	1	2	1	2	1	3	1	2	1	1	3	1
16	1/2	1	2	1	1	1/2	1	2	1	1/2	3	1	1	1	1/2	1	1	1	1/2	1	1	1	2	1	1	2
17	1	1/2	1	1/2	1/2	1	2	1	1	2	1	1/2	1	3	1	1	1	1/2	1	2	1/3	1	1	2	1	1
18	1/2	1	2	1	1	3	1/2	1/4	1	1/2	1	1	2	1	1/2	1	2	1	1	1	1	1/2	2	1	2	1
19	1	2	3	1	5	1	1/3	1	2	1	1/3	1	1	1/2	1	2	1	1	1	1/2	1	1	1	3	1	1/2
20	2	1/3	1	2	1	1	1	1	3	1	1/2	1	1/2	1	1/3	1	1/2	1	2	1	2	1	1	1/2	1	2
21	1/3	1	1	1	1/2	1	2	1	1	1	1	2	1	1/2	1	1	3	1	1	1/2	1	1	1/2	1	2	1
22	1/2	1	1/2	3	1	1	1	1	2	1/3	1	1/2	1	1	1/2	1	1	2	1	1	1	1	1	1	1	2
23	1/2	2	1	1	1	1	1/2	1/2	1	2	1	1	3	1	1	1/2	1	1/2	1	1	2	1	1	2	1/2	2
24	2	3	1	1	3	1	1	1	2	1	1/2	1	1	1/2	1	1	1/2	1	1/3	2	1	1	1/2	1	2	1
25	1	2	1	1/2	1	2	1	1/3	1	1	1	1/2	2	1	1/3	1	1	1/2	1	1	1/2	1	2	1/2	1	1
26	1	1/2	1	2	1	1	1/4	1	2	1	1	1	1/2	1	1	1/2	1	1	2	1/2	1	1/2	1/2	1	1	1
Total	25.83	30.5	31.5	28.33	31.92	33.5	28.58	31.08	33.33	25.33	27.67	27.5	32	31.5	23.67	28.33	30.33	30.83	29.37	30.83	29.83	29.83	28.83	28.67	34.5	33.5

DOI : https://doi.org/10.56452/7-12-49

Table 6 Normalized Decision Matrixes of Pair Wise Comparisons and Calculation of Critical Weights of Lean Manufacturing Enablers (LMEs)

LMEs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Criteria Weight (Average)
1	0.039	0.033	0.032	0.071	0.010	0.060	0.035	0.064	0.015	0.039	0.036	0.036	0.031	0.063	0.084	0.071	0.033	0.065	0.034	0.016	0.101	0.067	0.069	0.017	0.029	0.030	**0.05**
2	0.039	0.033	0.032	0.018	0.094	0.030	0.017	0.097	0.030	0.039	0.036	0.073	0.031	0.016	0.042	0.035	0.066	0.032	0.017	0.097	0.034	0.034	0.017	0.012	0.058	0.060	**0.04**
3	0.039	0.033	0.032	0.018	0.031	0.060	0.035	0.064	0.030	0.020	0.018	0.036	0.031	0.032	0.042	0.018	0.033	0.016	0.011	0.032	0.034	0.067	0.035	0.035	0.029	0.030	**0.03**
4	0.019	0.066	0.063	0.035	0.031	0.030	0.070	0.032	0.030	0.039	0.036	0.018	0.094	0.032	0.084	0.035	0.066	0.032	0.034	0.016	0.034	0.011	0.035	0.035	0.058	0.015	**0.04**
5	0.116	0.011	0.032	0.035	0.031	0.119	0.035	0.032	0.015	0.039	0.072	0.073	0.031	0.095	0.021	0.035	0.066	0.032	0.007	0.032	0.067	0.034	0.035	0.012	0.029	0.030	**0.04**
6	0.019	0.033	0.016	0.035	0.008	0.030	0.070	0.032	0.030	0.079	0.036	0.036	0.016	0.032	0.042	0.071	0.033	0.011	0.034	0.032	0.034	0.034	0.035	0.035	0.014	0.030	**0.03**
7	0.039	0.066	0.032	0.018	0.031	0.015	0.035	0.032	0.060	0.039	0.036	0.036	0.016	0.032	0.021	0.035	0.016	0.065	0.102	0.032	0.017	0.034	0.069	0.035	0.029	0.119	**0.04**
8	0.019	0.011	0.016	0.035	0.031	0.030	0.035	0.032	0.010	0.020	0.036	0.073	0.031	0.063	0.042	0.018	0.033	0.130	0.034	0.032	0.034	0.034	0.069	0.035	0.087	0.030	**0.04**
9	0.077	0.033	0.032	0.035	0.063	0.030	0.017	0.097	0.030	0.039	0.012	0.036	0.031	0.032	0.042	0.035	0.033	0.032	0.017	0.011	0.034	0.017	0.035	0.017	0.029	0.015	**0.03**
10	0.039	0.033	0.063	0.035	0.031	0.015	0.035	0.064	0.030	0.039	0.072	0.036	0.063	0.032	0.042	0.071	0.016	0.065	0.034	0.032	0.034	0.101	0.017	0.035	0.029	0.030	**0.04**
11	0.039	0.033	0.063	0.035	0.016	0.030	0.035	0.032	0.090	0.020	0.036	0.018	0.031	0.063	0.042	0.012	0.033	0.032	0.102	0.065	0.034	0.034	0.035	0.070	0.029	0.030	**0.04**
12	0.039	0.016	0.032	0.071	0.016	0.030	0.035	0.016	0.030	0.039	0.072	0.036	0.031	0.032	0.042	0.035	0.066	0.032	0.034	0.032	0.017	0.067	0.035	0.035	0.058	0.030	**0.04**
13	0.039	0.033	0.032	0.012	0.031	0.060	0.070	0.032	0.030	0.020	0.036	0.036	0.031	0.016	0.042	0.035	0.033	0.016	0.034	0.065	0.034	0.034	0.012	0.035	0.014	0.060	**0.03**
14	0.019	0.066	0.032	0.035	0.010	0.030	0.035	0.016	0.030	0.039	0.018	0.036	0.063	0.032	0.021	0.035	0.011	0.032	0.068	0.032	0.067	0.034	0.035	0.070	0.029	0.030	**0.04**
15	0.019	0.033	0.032	0.018	0.063	0.030	0.070	0.032	0.030	0.039	0.036	0.036	0.031	0.063	0.042	0.071	0.033	0.065	0.034	0.097	0.034	0.067	0.035	0.035	0.087	0.030	**0.04**
16	0.019	0.033	0.063	0.035	0.031	0.015	0.035	0.064	0.030	0.020	0.108	0.036	0.031	0.032	0.021	0.035	0.033	0.032	0.017	0.032	0.034	0.034	0.069	0.035	0.029	0.060	**0.04**
17	0.039	0.016	0.032	0.018	0.016	0.030	0.070	0.032	0.030	0.079	0.036	0.018	0.031	0.095	0.042	0.035	0.033	0.016	0.034	0.065	0.011	0.034	0.035	0.070	0.029	0.030	**0.04**
18	0.019	0.033	0.063	0.035	0.031	0.090	0.017	0.008	0.030	0.020	0.036	0.036	0.063	0.032	0.021	0.035	0.066	0.032	0.034	0.032	0.034	0.017	0.069	0.035	0.058	0.030	**0.04**
19	0.039	0.066	0.095	0.035	0.157	0.030	0.012	0.032	0.060	0.039	0.012	0.036	0.031	0.016	0.042	0.071	0.033	0.032	0.034	0.016	0.034	0.034	0.035	0.105	0.029	0.015	**0.04**
20	0.077	0.011	0.032	0.071	0.031	0.030	0.035	0.032	0.090	0.039	0.018	0.036	0.016	0.032	0.014	0.035	0.016	0.032	0.068	0.032	0.067	0.034	0.035	0.017	0.029	0.060	**0.04**
21	0.013	0.033	0.032	0.035	0.016	0.030	0.070	0.032	0.030	0.039	0.036	0.073	0.031	0.016	0.042	0.035	0.099	0.032	0.034	0.016	0.034	0.034	0.017	0.035	0.058	0.030	**0.04**
22	0.019	0.033	0.016	0.106	0.031	0.030	0.035	0.032	0.060	0.013	0.036	0.018	0.031	0.032	0.021	0.035	0.033	0.065	0.034	0.032	0.034	0.034	0.035	0.035	0.029	0.060	**0.04**
23	0.019	0.066	0.032	0.035	0.031	0.030	0.017	0.016	0.030	0.079	0.036	0.036	0.094	0.032	0.042	0.018	0.033	0.016	0.034	0.032	0.067	0.034	0.035	0.070	0.014	0.060	**0.04**
24	0.077	0.098	0.032	0.035	0.094	0.030	0.035	0.032	0.060	0.039	0.018	0.036	0.031	0.016	0.042	0.035	0.016	0.032	0.011	0.065	0.034	0.034	0.017	0.035	0.058	0.030	**0.04**
25	0.039	0.066	0.032	0.018	0.031	0.060	0.035	0.011	0.030	0.039	0.036	0.018	0.063	0.032	0.014	0.035	0.033	0.016	0.034	0.032	0.017	0.034	0.069	0.017	0.029	0.030	**0.03**
26	0.039	0.016	0.032	0.071	0.031	0.030	0.009	0.032	0.060	0.039	0.036	0.036	0.016	0.032	0.042	0.018	0.033	0.032	0.068	0.016	0.034	0.017	0.017	0.035	0.029	0.030	**0.03**
Total	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.00**

DOI : https://doi.org/10.56452/7-12-49

Table 7 Consistency Matrix of Pair Wise Comparisons and Calculation of Weighted Sum Value (WSV), Critical Weights (CW) Ratio between WSV/ CW and Average of Lean Manufacturing Enablers (LMEs)

LMEs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Weighted Sum Value	Critical Weights	Ratio WSV/CW
1	0.050	0.040	0.030	0.080	0.013	0.060	0.040	0.080	0.015	0.040	0.040	0.040	0.030	0.080	0.080	0.080	0.040	0.080	0.040	0.020	0.120	0.080	0.080	0.020	0.030	0.030	1.34	0.05	29.45
2	0.050	0.040	0.030	0.020	0.120	0.030	0.020	0.120	0.030	0.040	0.040	0.080	0.030	0.020	0.040	0.040	0.080	0.040	0.020	0.120	0.040	0.040	0.020	0.013	0.060	0.060	1.24	0.04	29.71
3	0.050	0.040	0.030	0.020	0.040	0.060	0.040	0.080	0.030	0.020	0.020	0.040	0.030	0.040	0.040	0.020	0.040	0.020	0.013	0.040	0.040	0.080	0.040	0.040	0.030	0.030	0.97	0.03	29.42
4	0.025	0.080	0.060	0.040	0.040	0.030	0.080	0.040	0.030	0.040	0.040	0.020	0.090	0.040	0.080	0.040	0.080	0.040	0.040	0.020	0.040	0.013	0.040	0.040	0.060	0.015	1.16	0.04	28.75
5	0.150	0.013	0.030	0.040	0.040	0.120	0.040	0.040	0.015	0.040	0.080	0.080	0.030	0.120	0.020	0.040	0.080	0.040	0.008	0.040	0.080	0.040	0.040	0.013	0.030	0.030	1.30	0.04	29.70
6	0.025	0.040	0.015	0.040	0.010	0.030	0.080	0.040	0.030	0.080	0.040	0.040	0.015	0.040	0.040	0.080	0.040	0.013	0.040	0.040	0.040	0.040	0.040	0.040	0.015	0.030	0.98	0.03	29.18
7	0.050	0.080	0.030	0.020	0.040	0.015	0.040	0.040	0.060	0.040	0.040	0.040	0.015	0.040	0.020	0.040	0.020	0.080	0.120	0.040	0.020	0.040	0.080	0.040	0.030	0.120	1.20	0.04	29.39
8	0.025	0.013	0.015	0.040	0.040	0.030	0.040	0.040	0.010	0.020	0.040	0.080	0.030	0.080	0.040	0.020	0.040	0.160	0.040	0.040	0.040	0.040	0.080	0.040	0.090	0.030	1.16	0.04	29.64
9	0.100	0.040	0.030	0.040	0.080	0.030	0.020	0.120	0.030	0.040	0.013	0.040	0.030	0.040	0.040	0.040	0.040	0.040	0.020	0.013	0.040	0.020	0.040	0.020	0.030	0.015	1.01	0.03	29.83
10	0.050	0.040	0.060	0.040	0.040	0.015	0.040	0.080	0.030	0.040	0.080	0.040	0.060	0.040	0.040	0.080	0.020	0.080	0.040	0.040	0.040	0.120	0.020	0.040	0.030	0.030	1.24	0.04	29.35
11	0.050	0.040	0.060	0.040	0.020	0.030	0.040	0.040	0.090	0.020	0.040	0.020	0.030	0.080	0.040	0.013	0.040	0.040	0.120	0.080	0.040	0.040	0.040	0.080	0.030	0.030	1.19	0.04	29.31
12	0.050	0.020	0.030	0.080	0.020	0.030	0.040	0.020	0.030	0.040	0.080	0.040	0.030	0.040	0.040	0.040	0.080	0.040	0.040	0.040	0.020	0.080	0.040	0.040	0.060	0.030	1.10	0.04	29.22
13	0.050	0.040	0.030	0.013	0.040	0.060	0.080	0.040	0.030	0.020	0.040	0.040	0.030	0.020	0.040	0.040	0.040	0.020	0.040	0.080	0.040	0.040	0.013	0.040	0.015	0.060	1.00	0.03	29.23
14	0.025	0.080	0.030	0.040	0.013	0.030	0.040	0.020	0.030	0.040	0.020	0.040	0.060	0.040	0.020	0.040	0.013	0.040	0.080	0.040	0.080	0.040	0.040	0.080	0.030	0.030	1.04	0.04	29.26
15	0.025	0.040	0.030	0.020	0.080	0.030	0.080	0.040	0.030	0.040	0.040	0.040	0.030	0.080	0.040	0.080	0.040	0.080	0.040	0.120	0.040	0.080	0.040	0.040	0.090	0.030	1.33	0.04	29.65
16	0.025	0.040	0.060	0.040	0.040	0.015	0.040	0.080	0.030	0.020	0.120	0.040	0.030	0.040	0.020	0.040	0.040	0.040	0.020	0.040	0.040	0.040	0.080	0.040	0.030	0.060	1.11	0.04	29.29
17	0.050	0.020	0.030	0.020	0.020	0.030	0.080	0.040	0.030	0.080	0.040	0.020	0.030	0.120	0.040	0.040	0.040	0.020	0.040	0.080	0.013	0.040	0.040	0.080	0.030	0.030	1.10	0.04	29.40
18	0.025	0.040	0.060	0.040	0.040	0.090	0.020	0.010	0.030	0.020	0.040	0.040	0.060	0.040	0.020	0.040	0.080	0.040	0.040	0.040	0.040	0.020	0.080	0.040	0.060	0.030	1.09	0.04	28.86
19	0.050	0.080	0.090	0.040	0.200	0.030	0.013	0.040	0.060	0.040	0.013	0.040	0.030	0.020	0.040	0.080	0.040	0.040	0.040	0.020	0.040	0.040	0.040	0.120	0.030	0.015	1.29	0.04	29.49
20	0.100	0.013	0.030	0.080	0.040	0.030	0.040	0.040	0.090	0.040	0.020	0.040	0.015	0.040	0.013	0.040	0.020	0.040	0.080	0.040	0.080	0.040	0.040	0.020	0.030	0.060	1.12	0.04	29.44
21	0.017	0.040	0.030	0.040	0.020	0.030	0.080	0.040	0.030	0.040	0.040	0.080	0.030	0.020	0.040	0.040	0.120	0.040	0.040	0.020	0.040	0.040	0.020	0.040	0.060	0.030	1.07	0.04	29.13
22	0.025	0.040	0.015	0.120	0.040	0.030	0.040	0.040	0.060	0.013	0.040	0.020	0.030	0.040	0.020	0.040	0.040	0.080	0.040	0.040	0.040	0.040	0.040	0.040	0.030	0.060	1.06	0.04	29.45
23	0.025	0.080	0.030	0.040	0.040	0.030	0.020	0.020	0.030	0.080	0.040	0.040	0.090	0.040	0.040	0.020	0.040	0.020	0.040	0.040	0.080	0.040	0.040	0.080	0.015	0.060	1.12	0.04	28.88
24	0.100	0.120	0.030	0.040	0.120	0.030	0.040	0.040	0.060	0.040	0.020	0.040	0.030	0.020	0.040	0.040	0.020	0.040	0.013	0.080	0.040	0.040	0.020	0.040	0.060	0.030	1.19	0.04	29.70
25	0.050	0.080	0.030	0.020	0.040	0.060	0.040	0.013	0.030	0.040	0.040	0.020	0.060	0.040	0.013	0.040	0.040	0.020	0.040	0.040	0.020	0.040	0.080	0.020	0.030	0.030	0.98	0.03	29.21
26	0.050	0.020	0.030	0.080	0.040	0.030	0.010	0.040	0.060	0.040	0.040	0.040	0.015	0.040	0.040	0.020	0.040	0.040	0.080	0.020	0.040	0.020	0.020	0.040	0.030	0.030	0.96	0.03	29.22
																												Average	29.35

Based on a variety of literatures, the relative value of each module's attributes was determined. The implementation starting module for lean manufacturing was discovered and found to be composed of twenty- six properties. The matrix of pair wise comparison for lean manufacturing enablers Table 5 was constructed according to the recommended numerical values to represent levels of favor between two products.

Following the acquisition of the pair wise comparisons, each element was divided by the aggregate number of its

DOI : https://doi.org/10.56452/7-12-49

corresponding columns to create a normalized decision matrix of the pair wise comparisons and the computation of critical weights of lean manufacturing enablers, and this is presented in Table 6 & Table 7.

The total of the twenty- six row elements together the average of those row elements (the principle vector) made up the sequence of entries in each of the two remaining columns of the normalized matrix table. As a result, the primary vector provides the approximate priority weight for each property.

Table 8 Critical Weight with each Lean Manufacturing Enablers (LMEs)

LMEs	Criteria Weight (Average)
LME 1	0.05
LME 2	0.04
LME 3	0.03
LME 4	0.04
LME 5	0.04
LME 6	0.03
LME 7	0.04
LME 8	0.04
LME 9	0.03
LME 10	0.04
LME 11	0.04
LME 12	0.04
LME 13	0.03
LME 14	0.04
LME 15	0.04
LME 16	0.04
LME 17	0.04
LME 18	0.04
LME 19	0.04
LME 20	0.04
LME 21	0.04
LME 22	0.04
LME 23	0.04
LME 24	0.04
LME 25	0.03
LME 26	0.03
Total	1.00

After obtaining the critical weights of lean manufacturing enablers, consistency matrix of pair wise comparisons and calculation of weighted sum value (WSV), critical weights (CW) ratio between WSV/ CW and average of lean manufacturing enablers (LMEs) was developed in Table 8. The acceptability of the previously mentioned attributes priority weighting can be ascertained by determining this comparison's consistency ratio (C. R.). It is an approximate mathematical guide or indicator of how consistently pair wise comparisons hold up.

It is given by the following equation.

Consistency Ratio (C. R.) = Consistency Index (C. I.) / Random Index (R. I.)

Where,

Consistency Index (C. I.) = [(λmax - N) / (N - 1)]

λmax = Average of Ratio WSV / CW = 29.35

Here, N = 26 this is determined by the matrix's size and, in this instance, a quantity of λmax 29.35.

Consistency Index (C. I.) = [(λmax - N) / (N - 1)]

C. I. = (29.35-26) / (26-1)

C. I. = 3.35 / 25

C. I. = 0.134

Hence the C. I. value was found to be 0.134.

DOI : https://doi.org/10.56452/7-12-49

Table 9 Different Matrix Size and Random Index Value (RI)

Figure 10
Random Indices

Matrix Size	3	4	5	6	7	8	9	10
RI	0.52	0.89	1.13	1.25	1.35	1.43	1.47	1.5
Matrix Size	11	12	13	14	15	16	17	18
RI	1.53	1.54	1.56	1.57	1.59	1.6	1.61	1.61
Matrix Size	19	20	21	22	23	24	25	26
RI	1.62	1.63	1.63	1.64	1.65	1.65	1.66	1.66
Matrix Size	27	28	29	30	31	32	33	34
RI	1.66	1.67	1.67	1.67	1.67	1.68	1.68	1.68
Matrix Size	35	36	37	38	39	40	41	42
RI	1.68	1.69	1.69	1.69	1.69	1.69	1.70	1.70
Matrix Size	43	44	45	46	47	48	49	50
RI	1.70	1.70	1.70	1.70	1.70	1.70	1.71	1.71

On the basis of Table 6.10, the Random Indexes standard value over the Matrix 26 * 26 is 1.66. [32]
Consistency Ratio (C. R.) = Consistency Index (C. I.) / Random Index (R. I.)
There,
Consistency Index (C. I.) = 0.134
From Table 9,
Random Index (R. I.) = 1.66
Consistency Ratio (C. R.) = 0.134 / 1.66 = 0.08
Consistency Ratio (C. R.) = 0.08
As a result, the C. R. value of 0.08 was discovered. For practical purposes, the consistency typically proves entirely appropriate if it is not higher than 0.1.

5.2 Priority Weights for Alternatives With Respect To Attributes - If these characteristics are strong, there is a greater probability of a lean manufacturing implementation becoming effective. The choice of an alternative with regard to an attribute is indicated by priority weights for alternatives (success or failure).
Therefore, the likelihood of success for SMEs in Uttar Pradesh will be greater whenever a strong attribute is present than when a weak attribute is present. The five options provided are used to determine the priority weights for alternatives, taking into consideration the strength of all characteristics found in SMEs in Uttar Pradesh.

Extremely Good	**5**
Good	**4**
Fair	**3**
Weak	**2**
Poor	**1**

A score of three or five suggests a strong likelihood of success. For instance, the user would rank the LME 1 attribute as good (5) if they thought that the existence of a clear marketing plan (LME 1) was committed. This demonstrates that the likelihood of successful implementation is five times higher than the likelihood of failure. The pair wise comparison of potential outcomes when it comes to attribute LME 1 is shown in Table 10.

DOI : https://doi.org/10.56452/7-12-49

Table 10 Matrix of Paired Comparison Result for Possible Outcomes and Normalized Matrix and Priority Weights of Possible Outcomes

Pair Wise Comparison Matrix		
	Success	**Failure**
Success	**1**	5
Failure	1/5	**1**
Total	1.2	6

Normalized Decision Matrix				
	Success	**Value/1.2**	**Failure**	**Value/6**
Success	**1**	0.833	5	0.833
Failure	1/5	0.167	**1**	0.167
Total	1.2	1.000	6	1.000

Critical Weight Calculation			
	Success	**Failure**	**Criteria Weight (Average)**
Success	0.833	0.833	0.833
Failure	0.167	0.167	0.167
Total	1.000	1.000	1.000

Consistency Matrix				
	Success	**Value*0.833**	**Failure**	**Value*0.167**
Success	**1**	0.833	5	0.835
Failure	1/5	0.167	**1**	0.167
Total	1.2		6	

Consistency Matrix with Sum					
	Success	**Failure**	**Criteria Weight (CW)**	**Weighted Sum Value (WSV)**	**Ratio WSV/CW**
Success	0.833	0.835	0.834	1.668	2
Failure	0.167	0.167	0.167	0.334	2
				AVERAGE	**2**

Findings from the process of assessing each of the twenty- six criteria for the implementation's potential outcome are compiled in Table 11. Assume that each attribute in the SMEs in Uttar Pradesh was rated by the user as adequate.

LME 1	Extremely Good (5)
LME 2	Good (3)
LME 3	Extremely Good (5)
LME 4	Good (3)
LME 5	Good (3)
LME 6	Fair (1)
LME 7	Good (3)
LME 8	Extremely Good (5)
LME 9	Good (3)
LME 10	Extremely Good (5)
LME 11	Extremely Good (5)
LME 12	Extremely Good (5)
LME 13	Good (3)
LME 14	Extremely Good (5)
LME 15	Good (3)
LME 16	Good (3)
LME 17	Fair (1)
LME 18	Good (3)
LME 19	Extremely Good (5)
LME 20	Good (3)
LME 21	Extremely Good (5)
LME 22	Extremely Good (5)
LME 23	Extremely Good (5)
LME 24	Good (3)
LME 25	Extremely Good (5)
LME 26	Good (3)

Table 11 Summary of all Paired Comparisons and Resulting Priority Weight for Possible Outcomes with respect to Each Attributes

		Success	Failure	Criteria Weight (Average)
LME 1	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 2	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 3	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 4	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 5	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 6	**Success**	**1**	1	0.5
	Failure	1	**1**	0.5
LME 7	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 8	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 9	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 10	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 11	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 12	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 13	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 14	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 15	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 16	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 17	**Success**	**1**	1	0.5
	Failure	1	**1**	0.5
LME 18	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 19	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 20	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 21	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 22	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 23	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 24	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249
LME 25	**Success**	**1**	5	0.833
	Failure	1/5	**1**	0.167
LME 26	**Success**	**1**	3	0.751
	Failure	1/3	**1**	0.249

5.3 Priority Weights for Prediction – Table 11 provides an overview of all priority weights for each outcome, organized in a way that renders it easy to calculate the final result.

- Table 12's first row provides the attribute weights (from Table 5).
- The body of Table 12 contains the evaluation ratings about the accuracy of each forecast (from Table 6).
- The right-hand column of Table 12 displays the weighted assessment outcomes that were determined for each forecast.

DOI : https://doi.org/10.56452/7-12-49

Table 12 Summary of Priority Weights

LMEs	Attribute Weight (Average)	Success	Failure
LME 1	0.045	0.833	0.167
LME 2	0.042	0.751	0.249
LME 3	0.033	0.833	0.167
LME 4	0.040	0.751	0.249
LME 5	0.044	0.751	0.249
LME 6	0.034	0.5	0.5
LME 7	0.041	0.751	0.249
LME 8	0.039	0.833	0.167
LME 9	0.034	0.751	0.249
LME 10	0.042	0.833	0.167
LME 11	0.041	0.833	0.167
LME 12	0.038	0.833	0.167
LME 13	0.034	0.751	0.249
LME 14	0.036	0.833	0.167
LME 15	0.045	0.751	0.249
LME 16	0.038	0.751	0.249
LME 17	0.038	0.5	0.5
LME 18	0.038	0.751	0.249
LME 19	0.044	0.833	0.167
LME 20	0.038	0.751	0.249
LME 21	0.037	0.833	0.167
LME 22	0.036	0.833	0.167
LME 23	0.039	0.833	0.167
LME 24	0.040	0.751	0.249
LME 25	0.033	0.833	0.167
LME 26	0.033	0.751	0.249
Prediction Weight (Average)		**0.8**	**0.2**
		Total of Success and Failure	**1**

6. DISCUSSION

To determine the order of relevance for the enablers, the study ranked them through a survey. 34 responses were gathered from 293 surveys that were distributed, yielding an 11.6% response rate. Using a Likert scale, wherein one denotes “not important” and five denotes “most important”, the respondents were tasked with categorizing the facilitators. The facilitators and average importance level evaluations are shown in Figure 3.

As illustrated in Figure 3, “a thorough comprehension of the technical prerequisites for lean methodologies” possessed an average rating of “432”, making it the most prominent enabler of Lean adoption. Second, embracing a “streamlined mindset” and the “administration dedication” have been demonstrated to be the most important elements of Lean the adoption process, obtaining an average rating of “426” and “423”, correspondingly. With average ratings of “314” and “317”, respectively, “market share” and “encouraging features of governmental regulations in Lean” have been categorized as somewhat important.

7. CONCLUSION

AHP model has been developed by identifying the best set of LMEs which can act as enablers for lean manufacturing implementation. The predictive property of the Analytical Hierarchical Process (AHP) model can help the SMEs for Uttar Pradesh highest management in industries in implementing lean manufacturing in a better way. The pre- implementation phase is covered by this initiation module. Given that it offers the Uttar Pradesh SMEs with a blueprint for implementing lean manufacturing, it could be considered the most significant stage. The literature review is used for determining the key lean manufacturing (LM) elements, and the model is created for a generic LM implementation. The key determinants for a given implementation must be recognized and assigned the proper weights in relation to other attributes and determinants, especially if they differ from those that are employed or if the relative priority weights differ. The level of accuracy to which the users accurately ranked the LMEs that are accessible in the Uttar Pradesh SMEs determines how accurate the model can forecast.

For taking the right decision it is important to choose the best set of LMEs for LM implementation. AHP has been used here for deciding the best set of LMEs. Most of the time, Uttar Pradesh’s SMEs lack the resources- both time and committed specialists- to adequately research these kinds of medium- to long-term strategic challenges. The senior leadership of SMEs in Uttar Pradesh monitors a flatter industrial infrastructure and has less time to dedicate to medium-

DOI : https://doi.org/10.56452/7-12-49

and long-term strategic planning due to day- to- day operations. Uttar Pradesh SMEs do not have the knowledge or time to evaluate the lean manufacturing (LM) implementation. Successful LM implementation in Uttar Pradesh SMEs It is most effectively achieved by assisting them in making more informed judgments.

AHP is decision making tool and these may assist speed up the procedure of making decisions. The predictive property of the AHP process can help the Uttar Pradesh SMEs in implementing lean manufacturing in a better way. The analysis and results as obtained from AHP analysis will act as a roadmap for disseminating knowledge and raising consciousness in Uttar Pradesh SMEs on the degree of adjustments necessary or in addition to an instrument of verification that can aid in the successful application of lean manufacturing. The manufacturing sector is dynamic and fragmented. As a result, the industry has to contend with some ambiguities and disputes in addition to difficulties with productivity, quality, and safety. Manufacturing processes are best managed by introducing Lean implementation to the industry to prevent these kinds of problems or to lessen and regulate their consequences.

Nonetheless, most manufacturing industry practitioners still find it difficult to implement lean due to a variety of factors, including a lack of knowledge of lean, a misunderstanding of lean methods, or a lack of experience with implementing lean. Therefore, the goal of the following piece is to create a collection of Lean enablers that will help small and medium- sized businesses successfully implement Lean. In this regard, the study identified twenty- six enabling components that were examined under seven-factor groupings. Through a poll given to Lean practitioners, the analysis also graded these elements according to their relative relevance. According to the survey, Lean practitioners emphasize that having an extensive knowledge of the technological requirements of Lean is essential for effectively managing the implementation process. However, the respondents also point out that the biggest obstacle to Lean implementation remains a lack of support among upper management.

REFERENCES

[1] Global Construction Outlook 2020, trimetric, Mar 2016. https://www.prnewswire.com/newsreleases/global-construction-market-worth-103 trillion-in-2020-50-largest-most-influentialmarkets-292235961.html on 12 February 2018.

[2] Meadows, D. (2011). Designing out Waste. Environmental Design and Construction, http://www.modular.org/marketing/documents/DesigningoutWaste_EDC.pdf (Accessed on 03.06.2017).

[3] Lean Construction Institute, What Is Lean Construction? <http://www.leanuk.leanconstruction.org/whatis.htm>, 2004.

[4] Aziz R. F. and Hafez S.M., "Applying lean thinking in construction and performance improvement," *Alexandria Eng. J.*, vol. 52, no. 4, pp. 679–695, 2013.

[5] Porter, M.E., "Competitive Advantage", Ch. 1, pp 11-15, *The Free Press*, New York, 1985.

[6] Koskela, L., "Application of the new production philosophy to construction", *Technical report No. 72*, Centre for Integrated Facility Engineering, Stanford University, CA, 1992.

[7] Womack, J.P. and Jones, D.T., "Lean Thinking: Banish Waste and Create Wealth in Your Corporation", *Simon & Schuster*, New York, NY, 1996.

[8] Howell, G.A., "What is lean construction", *Proceedings of the 7th International Group for Lean Construction*, University of California, Berkeley, CA, USA, 1999.

[9] Koskela, L., "Making-do: the eight category of waste", *12th Annual Conference of the International Group for Lean Construction*, August 3-5, Helsingor, Denmark, 2004.

[10] Sundar R., Balaji A.N. and Satheesh Kumar R. M., "A review on lean manufacturing implementation techniques", *Procedia Eng.*, vol. 97, pp. 1875–1885. doi:10.1016/j.proeng.2014.12.341, 2014.

[11] Liker J.K. and Convis G.L., The Toyota Way to Lean Leadership, McGraw-Hill Companies, United States, ISBN 978-0-07-178078-0, 2012.

[12] Krafcik, J. F., "Triumph of the Lean Production system", *Sloan Mgmt. Rev.*, Vol. 30, No.1, pp. 41-51, 1988.

[13] Sarhan S. and Fox A., "Barriers to Implementing Lean Construction in the UK Construction Industry", *Built Hum. Environ. Rev.*, vol. 6, pp. 1–17, 2013.

[14] Radhika R and S. Sukumar, "An Overview of the Concept of Lean Construction and the Barriers in Its Implementation", *Int. J. Eng. Technol. Manag. Res.*, vol. 4, pp. 13–26, doi: 10.5281/zenodo.478010., 2007.

[15] G. Shang and L. Sui Pheng, "Barriers to lean implementation in the construction industry in China", *J. Technol. Manag. China*, vol. 9, pp. 155–173, doi:10.1108/JTMC-12-2013-0043, 2014.

[16] Terry, A. and Smith, S. Build Lean. Transforming construction using Lean Thinking, *CIRIA*, London, 2011.

[17] Diekmann, J.E., Krewedl, M., Balonick, J., Stewart, T. and Won, S., "Application of lean manufacturing principles to construction", *CII Report (project team 191)*, The University of Texas at Austin, Texas, 2004.

[18] Salem, O., Solomon, J., Genaidy, A. and Minkarah, I., "Lean construction: from theory to implementation", *Journal of Management in Engineering*, Vol. 22 No. 4, pp. 168-175, 2006.

[19] Abdelhamid, T.S., El-Gafy, M. and Salem, O., "Lean construction: fundamentals and principles", *American Professional Constructor Journal*, Vol. 4, pp. 8-19, 2008.

[20] Wandahl S., "Lean Construction with or without Lean – Challenges of Implementing Lean Construction", *Theory, Proceedings IGLC-22*, Oslo, Norway, June 2014.

[21] Kumar S., "Enablers of Lean Six Sigma Implementation in Business Environment: A Review" *Proceedings of International Conference on Smart Technologies for Mechanical Engineering*, pp. 409–417, 2013.

[22] Jagdish R. Jadhav, Shankar S. Mantha and Santosh B. Rane, "Exploring barriers in lean implementation", *International Journal of Lean Six Sigma*, Vol. 5 Issue: 2, pp.122-148, https://doi.org/10.1108/IJLSS-12-2012-0014, 2014.

[23] Almanei M., Salonitis K. and Y. Xu, "Lean Implementation Frameworks: The Challenges for SMEs", *Procedia CIRP*, Vol. 63, pp. 750–755. doi:10.1016/j.procir.2017.03.170, 2017.

[24] Oyedolapo O., "Implementation of the Lean Approach in Sustainable Construction: A Conceptual Framework", *PhD. Thesis*, Lancashire, Central, pp441, 2014.

[25] Okere G.O., Barriers and Enablers of Effective Knowledge Management: A Case in the Construction Sector, vol. 15 pp. 85–97, 2017.

[26] Alinaitwe H., "Prioritising Lean Construction Barriers in Uganda's Construction Industry", *J. Constr. Dev. Ctries*, vol. 14, pp. 15–30, 2009.

[27] Demirkesen S. and Tommelein I.D., "Lean Management Methods for Design and Construction: Built-in-Quality and Safety-by-Design", *Advances in Civil Engineering Conference Istanbul (ACE2016)*, pp. 1–8, 2016.

[28] Salem O., Solomon J., Genaidy A. and Luegring M., "Site Implementation and Assessment of Lean Construction Techniques", *Lean Construction*

Journal, vol. 2, 2005.

[29] Leite H., Bateman N. and Radnor Z., "Lean implementation and sustainability: a classification model of the main organizational barriers and enablers", *Production and Operations Management Society Conference* 1–10.

[30] Ali R.M. and Deif A.M., "Dynamic lean assessment for Takt time implementation*", Procedia CIRP,* vol. 17, pp. 577–581. doi:10.1016/i.procir.2014.01.128., 2014.

[31] Abdelnaser Omran A.A., "Barriers To Prioritizing Lean Construction", *ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering*, vol. 1, 2015.

[32] Howell G., Ballard G. and Demirkesen S., "Why Lean Projects Are Safer", *In LC3 2017: Proceedings of the 25th Annual Conference of the International Group for Lean Construction (IGLC)*, pp. 895–901. doi:10.24928/2017/0116 ,2017.

[33] Sorokhaibam K. and Chandan B., "Modeling the key barriers to lean construction using interpretive structural modeling", *Journal of Modelling in Management*, Vol. 12 Issue: 4, pp.652-670, https://doi.org/10.1108/JM2-07-2015-0052 Permanent, 2017.

[34] Dave B., Koskela L. and Kiviniemi A., "Implementing Lean in construction", *CIRIA*, Classic House, 174–180 Old Street, London, EC1V 9BP, UK, doi:10.1016/j.autcon.2010.09.013, 2013.

[35] Tommelein, I., Ballard, G., "Lean Construction Glossary", *Project Production Systems Lab (P2SL)*, Version 2.9., Berkeley, CA, 2017.

[36] Al-Husain, R., & Khorramshahgol, R. 2020, "Incorporating analytical hierarchy process and goal programming to design responsive and efficient supply chains". Operations Research Perspectives, Vol. 7, 100149. https://doi.org/10.1016/j.orp.2020.100149.

[37] Aburas, M. M., Abdullah, S. H. O., Ramli, M. F., & Asha'Ari, Z. H., 2017, "Land Suitability Analysis of Urban Growth in Seremban Malaysia, Using GIS Based Analytical Hierarchy Process". Procedia Engineering, Vol. 198, pp. 1128–1136. https://doi.org/10.1016/j.proeng.2017.07.155.

[38] E.H. Forman, S.I. Gass, 2017, "The analytical hierarchy process – An exposition", Oper. Res. Vol. 49, Issue 4, pp. 469–486, https://doi.org/10.1287/opre.49.4.469.11231.

[39] Abolhassani, A., Layfield, K. and Gopalakrishnan, B. 2016, "Lean and US manufacturing industry: popularity of practices and implementation barriers", International Journal of Productivity and Performance Management, Vol. 65 No. 7, pp. 875-897.

[40] Abu, F., Gholami, H., Saman, M.Z.M., Zakuan, N. and Streimikiene, D. 2019, "The implementation of lean manufacturing in the furniture industry: a review and analysis on the motives, barriers, challenges, and the applications", Journal of Cleaner Production, Vol. 234, pp. 660-680.

[41] Adzrie, M., Elcy, K., Joselyn, R. M., Mohd-Lair, N., & Chai, F. O. 2020, "Implementation selected tools of lean manufacturing". Journal of Physics: Conference Series, Vol. 1529, Issue 4.

[42] Ananthu krishna, A. 2019, "The effectiveness of implementing lean manufacturing techniques". International Journal of Management, Vol. 10, Issue 2.

[43] Belhadi, A., Touriki, F.E. and Elfezazi, S. 2019, "Evaluation of critical success factors (CSFs) to lean implementation in SMEs using AHP", International Journal of Lean Six Sigma, Vol. 10 No. 3, pp. 803-829.

[44] Birkie, S.E. and Trucco, P. 2016, "Understanding dynamism and complexity factors in engineer-to order and their influence on lean implementation strategy", Production Planning and Control, Vol. 27 No. 5, pp. 345-359.