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# MODELING AND ANALYSIS OF LEAN MANUFACTURING STRATEGIES USING ISM-FUZZY MICMAC APPROACH

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***Abstract:*** *The current research work deals with an identification of different lean strategies and extraction to relevant strategies after discussion with experts and gives the answer of a question "how lean manufacturing strategies can help the organization to enhance the efficiency of the organization with great effectiveness?" In this research work, thirty-six lean strategies have been identified and out of which thirteen lean strategies were filtered in respect of highly importance value by factor analysis using software SPSS 21. Further, to identify and analyze the inter-relationship among filtered strategies, an Interpretive Structural Modeling (ISM) with Fuzzy Matriced' Impacts Croise´s Multiplication Applique´e a UN Classement (MICMAC) approach has been used. Fuzzy MICMAC help to understand the dependence and driver's power of the lean strategies. The mutual importance of extracted strategies has been discussed through developing the ISM model and the individual assessment of each strategy with each of the other strategies has been derived using the Fuzzy MICMAC approach.*

***Key words***: *Lean Manufacturing System (LMS), Lean Strategies; Factor Analysis, SPSS 21, ISM Methodology, Fuzzy MICMAC*

## 1. Introduction

In the present scenario, it has been observed that the manufacturing firms are facing many challenges worldwide like quality, productivity, time management etc. To overcome these challenges forced the world's manufacturing firms to develop new manufacturing methods and concepts in the competitive market. Among them one of the main concepts is execution of lean manufacturing strategies in the production system. The concept of lean manufacturing system (LMS) was initiated by a Japanese automobile industry Toyota in mid-20th century was well known for production

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system. The aim of Toyota Production system was to enhance and raise the productivity with cost-reduction of the product by reducing waste or non-value added ventures (Womack et al., 1990; Srinivasaraghavan & Allada, 2006). It defines the production process and procedures to improve the working environment of the shop floor consequently it also helps in increasing the overall productivity of company (Narasimhan et al., 2006; Kusrini et al., 2014). It can provide the essential extended term performance to automobile companies by refining the organization of cost effectiveness, elimination of wastage and also environmental risks over the improvement of experiences for endless organizational progress. Lean manufacturing can implement the various set of activities for better performance of a company (Yusup et al., 2015; Al-Tit, 2017). There are different techniques generally accessing in the industry for effective outcomes. Application of lean manufacturing strategies can lead to continuous improvement in industrial field. The concept of lean can be implemented in any business organization along with the industries. Different types of tool are being used from past several decades in order to get error free production from production unit. It is a tool that provides effective results to withstand the competition in prevailing different segments in the market aiming to remove all others unnecessary parameters from production unit (Schiele & McCue, 2010). It uses very small inventory for manufacturing of product at high productivity. That's why, it can be seen as a very popular tool or technique used by most of big industries and firms.

Lean management is meant for respect of humanity, it does not under estimate the capacity of people working in the company. Moreover, it will help people to be more effective and appreciate their work. Lean management maintains the production and levelise all stages of production in the company (Ahlstrom, 2004; Nenni et al., 2014). Many errors occur during production like breakdown, lot reject etc. it can provide the framework to remove all these errors during the production. It can analyze the production procedure to find out the causes occur during production. Lean can help in maintaining the documentation of work process or procedure of production and establish the standards of the manufacturing for the company for present and future production (Jasti & Kodali, 2016). Many articles have focused on lean manufacturing strategies and lean integrated production system (Hackman & Wageman, 1995; McKone et al., 2001). This research purposes to pinpoint several lean strategies and features through comprehensive textual review to analyze them through interpretive structural modeling (ISM). A model based on ISM technique is developed to frame the immediate connection between various considered strategies. Then the fuzzy MICMAC technique is performed to measure the inter-dependent power of different lean strategies. The results of present effort will assist the managers to improve the efficiency of their firm in this competitive market.

In the current study, an ISM approach with fuzzy MICMAC analysis has been applied due to its various importances over the other MCDM approaches. This approach provides a model based on that the dependence and driving nature of any factor/measures/strategies which is missing with the application of other MCDM approaches. Furthermore, the MICMAC analysis under uncertain environment (fuzzy) provide the cluster based analysis through four sectors (dependent, independent, linkage or individual) which provides a platform to the manager or policy makers to emphasize on strategies or factors according to the policy notion of the concerned organization.

The organization of this research article is as follow: section one gives a brief introduction on the various lean strategies and their importance in present manufacturing scenario, section two encloses the inclusive literature review and the based that important lean strategies have been extracted, section three illustrates the methodology which has been applied on the selected strategies in order to obtain the interrelationship among them, the conclusion drawn from the present research and its managerial implications in manufacturing environment have been expressed in section four and five respectively. In the last, section six shows the limitation and future scope of the present study.

## 2. Literature review

The goal of LMS is to reduce inventory and increase human efficiency and handling industrial stocks which are in accordance to consumer needs and the products are manufactured effectively and efficiently (Bhim et al., 2010). Increasing resource effectiveness by excluding superfluous consumption denotes the logical extension from lean manufacturing to lean and manufacturing. A simulation based methodology for monetary valuation was studied by Greinacher et al., (2015) of lean and green manufacturing organizations as non-monetary green parameters. Thus, economical efficiency is an indispensable evaluating factor in the application of lean and green manufacturing strategies. Salleh et al., (2012) Studied the forming process for simulation of combined total quality management along with lean manufacturing activities. Wahab et al., (2013) established a theoretical model to evaluate leanness in manufacturing unit. In this research, a concept based model for leanness element in the manufacturing unit has been made and deliberate in two prime levels i.e. dimensions and factors. Additionally, the model also demonstrations how lean parameters of an organization or manufacturing system co- relating different forms of wastes. Hartini & Ciptomulyono (2015) examined the effect of lean and sustainable production system to improve organization performance. Onyeocha et al., (2015) worked on assessment of multi-product lean manufacturing system with assembly and changing demand.

Many of the suggestions recommended that lean production system is favorable for sustainable production system; most influentially, it would help in perspective environment and cost-effective aspects. Duraccio et al., (2014), Arslankaya & Atay (2015) observed and apply the maintenance management with the lean manufacturing methods at the maintenance workshop for removing the losses caused by breakdowns in order to improve production and motivate the personnel. Youssouf et al., (2014) worked on the optimization of strategies lean Six Sigma. Lean manufacturing with ergonomic working environment in the automobile sector is another very effective concept to enhance the working condition, improve productivity, improving production processes, and eliminate the waste (Berlin et al., 2014; Dos Santos et al., 2015). The key area of ergonomics is to improve and relate the man alteration methods to their work and competent and harmless ways in order to enhance the welfare, safety, health, prosperity and thus to accumulate efficiency and productivity of the organization (Dul & Neumann, 2009). Mohammaddust et al., (2017) developed the robust lean model for alternative risk mitigation strategies. Rohani & Zahraee (2015) studied lean manufacturing technique termed as Value Stream Mapping (VSM) for enhancing the assembly line of an industry. To attain this goal, lean strategies were applied in order to construct VSM for identification, disposal of wastages and improved performance of the organization. Susilawati et al., (2015) used the fuzzy logic based process to quantify the level of lean activity in industry.

Mandal & Deshmukh (1994) researched about the vendor selection procedure of the company dependent on different parameters using ISM. ISM methodology is a very popular technique to define the direct relationship among different enablers or barriers. Lee et al., (2011) analysed that the Lean manufacturing is very popular technique in the field of production system from past several decades. Kanban system among them is the most important lean manufacturing principles for lean production system along with reduced cost and marginal inventories. The objectives are (i) to define the working of the KANBAN system successfully across organizations globally and (ii) categorizing factors obstructing small and medium enterprises from executing Kanban in lean manufacturing system (Rahman et al., 2013). Shah & Ward (2003) observed the outcomes of three dependent issues, plant dimensions, plant life and unionization position, on the chance of applying different manufacturing industrial practices that are main facets of LMS. Lee et al., (2011) analyzed the process-advantages, expenses, and threats for identifying techniques by making use of integrated ISM and fuzzy analytic order of procedure. Shuaib et al., (2016) studied on enablers of smart organization and developed the integrated ISM model with fuzzy MICMAC. Dewangan et al., (2015) examined the enablers for advancement of innovation in the Indian manufacturing segment and direct relationship has been analyzed among different enablers with help of ISM and fuzzy MICMAC. Charan et al., (2008) explored the barriers in supply chain performance measurement system and implementation in Indian context. ISM technique to analysis the enablers and barriers of green supply chain management (GSCM) has been used by many researcher, some of them are as follows (Diabat & Govindan, 2011; Gorane & Kant, 2013; Faisal, 2010; Mudgal et al., 2010; Singh et al., 2010; Talib et al., 2011; Tyagi et al., 2015; Wang et al., 2015; Tyagi et al., 2017). Kannan et al. (2009) applied the combined study of ISM and fuzzy TOPSIS approach to examine and considering the 3-P reverse logistic providers. Diabat & Govindan (2011) have suggested the ISM approach to examination the drivers influencing the application of GSCM. Prasad et al., (2020) developed a novel framework based on lean manufacturing concept for continuous improvement in Indian textile industry. Palang & Dhatrak (2020) implemented Define, Measure, Analysis, Improve and Control (DMAIC), Failure Mode and Effect Analysis (FMEA), Industry 4.0 and Kaizen approaches for developing the lean manufacturing concept based model in order to improve the productivity of the industry. Yadav et al., (2020) proposed hybrid Fuzzy Analytical Hierarchy Process (FAHP) - Decision Making Trial and Evaluation Laboratory (DEMATEL) approaches based lean manufacturing concept for enhancing the improvement capabilities of companies under developing economies. Guillen et al., (2020) proposed a structured methodology based on lean manufacturing principles for improving facility management. Tortorella et al., (2021) proposed lean automation based model for examining improvement pathway of an industry.

From the reviewed literature it has been noted that the application of ISM-MICMAC approaches was not yet been reported by any researcher in order to identify and analyze the inter-relationship among filtered strategies for the considered lean manufacturing case. To bridge this, gap the current work presents the application of

ISM-MICMAC approaches based framework to enhance the efficiency of the considered organization.

## 3. Research Methodology

On the basis of discussion with experts and literature review lean manufacturing strategies were identified and a developed questionnaire was floated among the experts for the collection of the data. Factor analysis was performed, and appropriate strategies were filtered and further brainstorming session was conducted for their acceptance or rejection. After the acceptance of filtered strategies ISM and fuzzy MICMAC approaches were applied and analysis was carried for reaching appropriate decision. The flow diagram on the research work plan denoted in figure 1 is carried out in unique view. However, a step by step explanation of ISM approach is also given below.

The interpretive structural modeling (ISM) used to create a composite system into an envisioned ordered arrangement. It is used for studying and solving complex problems to help in decision-making (Warfield, 1974; Jain & Raj, 2015). It is based on computer-assisted method that usually used to conclude the multiplex situations by providing a sensible and reasonable path of action (Kannan et al., 2009).

Initial phase of the ISM method is used to pin-point lean strategies, drivers or other alternatives, which concerns the research complication. Then a theoretically feasible derived relation is selected (Thakkar et al., 2006).

ISM methodology involves several steps as follows (Kannan &Haq, 2007; Sharma & Garg, 2010).

Identify and enlist the diverse strategies of lean manufacturing system.

I. Creating a relative relationship between different lean manufacturing strategies.

II. Development of a fundamental self-interaction matrix (SSIM) to lean manufacturing strategies which show interactions among lean manufacturing strategies under the ambit.

III. Creating reachability matrix using SSIM and then transitivity of the matrix is evaluated.

IV. A flow chart is drawn on the basis of reachability matrix.

V. Interpret the subsequent relationship digraph into an ISM by switching lean strategies with statements

Verify for conceptual difference and essential improvements made and contextual correlation was developed among diverse lean manufacturing strategies.

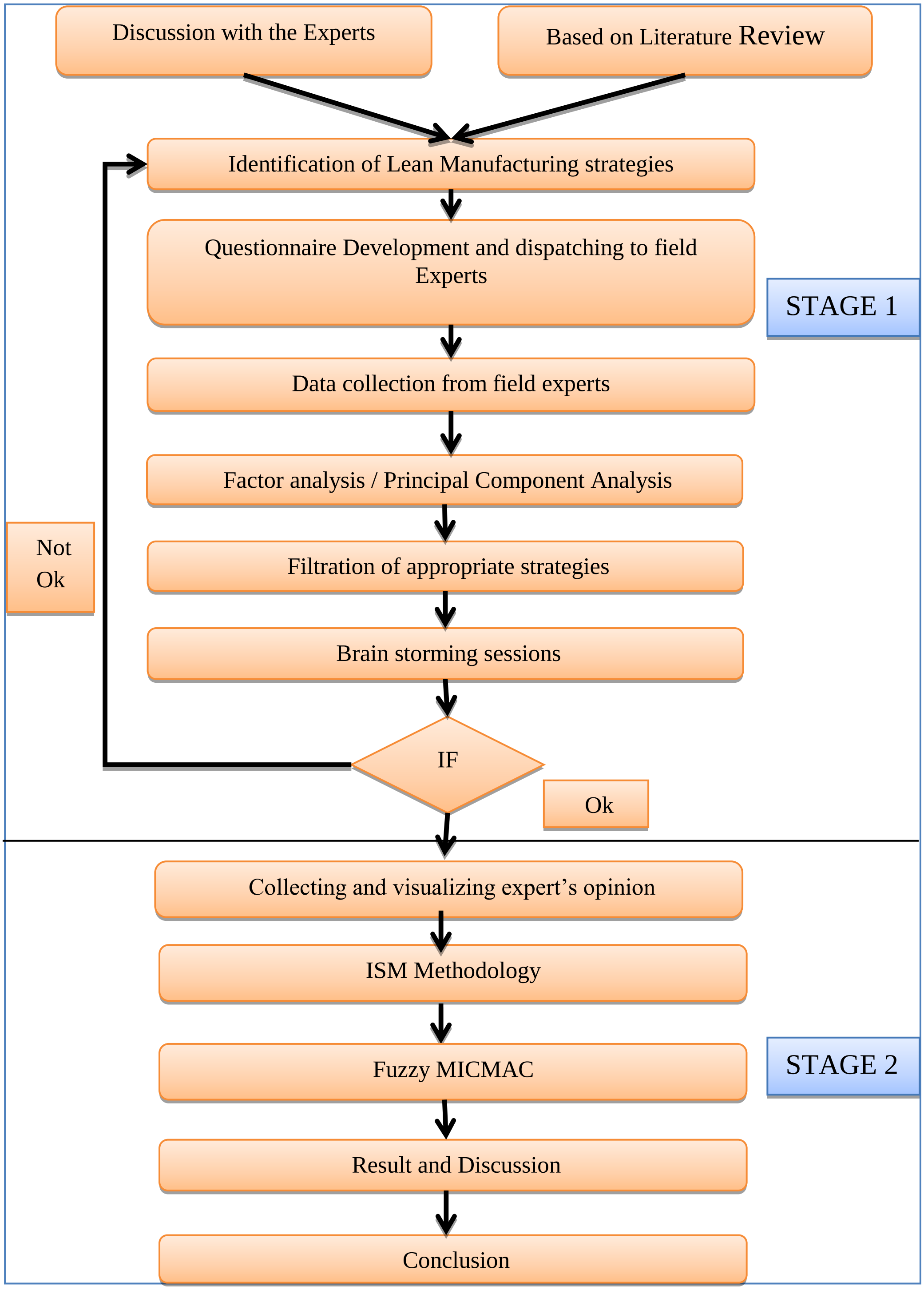



*Figure 1. Flow chart illustrating research direction*

## 4. Proposed research methodology implementation based results

In accordance to the literature survey and after consultation with the field professionals, thirty-six lean manufacturing strategies were acknowledged. Then, a questionnaire was designed using Google form and forwarded on Google doc. Numerous views of different field professionals were collected. To analyze the lean strategies, the experts from Indian automobiles companies situated near Delhi NCR and academicians from several organizations were communicated for the view of lean manufacturing strategies. encompassing expertise in the field of manufacturing and strategies formulation have been considered to collect their opinions regarding the implementation of lean strategies in Indian automobile companies in order to improve their performance. To analyze the lean strategies, an ISM approach with fuzzy MICMAC has been applied, for the same qualitative input from the experts (four groups having five to six experts in each group) have been taken to develop the structural self-interaction matrix. Here concept of fuzzy set is used to consider the vagueness of the collected data for high accuracy in the decision results. Before implementing the ISM approach, a factor analysis has also been carried in order to extract the significant strategies based on their factor loading values.

Factor analysis (FA) is a dynamic means for statistical mitigation and conveying the nearby events of diverse strategies by deciding the normal elements in view of the account of perceived correlations (Hayton, 2004). Primarily, a questionnaire has been designed by5-point Likert type scale for thirty-six lean strategies and was send to the one hundred and fifty field professionals to gather their view regarding the significance of lean strategies. Out of one hundred and fifty, fifty-seven replies were acknowledged, which reveals the 38% response rate. When the response rate is greater than 30%, it is appropriate to execute the reliability examination as suggested by Malhotra & Grover (1998).

The received stats are deemed as reliable, only if the cronbach alpha coefficient($\alpha$)ranges from0.7to 1. Gliem & Gliem (2003) mentions the rules as follows: $\alpha$> 0.9 signifies Outstanding, $\alpha$ > 0.8 signifies Good, $\alpha$ >0 .7 signifies Satisfactory, $\alpha$ > 0.6 signifies Questionable, $\alpha$ > 0.5 signifies Poor, and $\alpha$ < 0.5 signifies Unacceptable". In the present research work, score of the cronbach alpha coefficient comes as 0.794, hence the collected data can be considered as reliable. Then factor analysis is done for the clarification of appropriate lean strategies by same software. Table 1 shows cumulative variances of different lean strategies and thirteen lean strategies contributed to about 77.648 % of the total variance and have eigen values greater than threshold value of 1. The component matrix was observed to extract thirteen lean strategies based on the variable loaded in the software. The listed of extracted lean strategies is shown in table 2. To understand the dominance thirteen extracted lean strategies over the total identified strategies a scree plot has been structured, as shown in Figure 2. The scree plot makes an elbow after the thirteenth component, which means that each succeeding factor accounts for smaller and smaller accounts of the total variance.

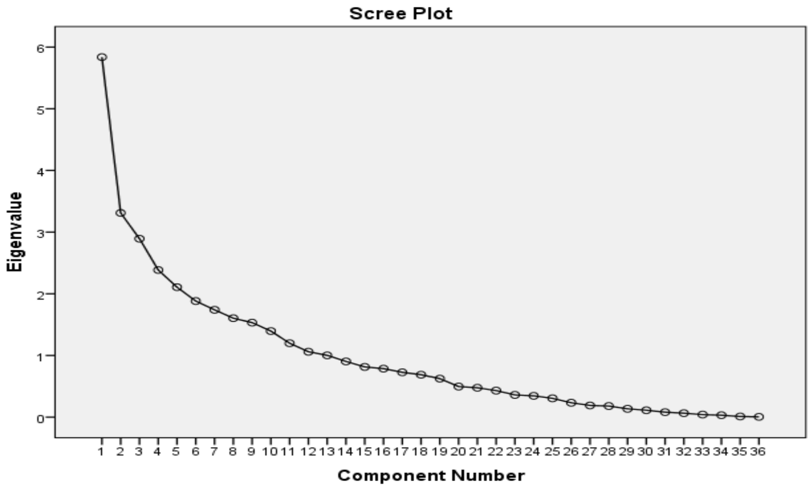



*Figure 2 Scree graph for different components*

*Table 1 Total variance explained*

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings |
|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total |
| 1 | 5.838 | 16.216 | 16.216 | 5.838 | 16.216 | 16.216 | 2.764 |
| 2 | 3.311 | 9.196 | 25.412 | 3.311 | 9.196 | 25.412 | 2.745 |
| 3 | 2.894 | 8.038 | 33.450 | 2.894 | 8.038 | 33.450 | 2.608 |
| 4 | 2.386 | 6.628 | 40.078 | 2.386 | 6.628 | 40.078 | 2.557 |
| 5 | 2.107 | 5.854 | 45.932 | 2.107 | 5.854 | 45.932 | 2.547 |
| 6 | 1.882 | 5.229 | 51.161 | 1.882 | 5.229 | 51.161 | 2.420 |
| 7 | 1.741 | 4.836 | 55.997 | 1.741 | 4.836 | 55.997 | 2.220 |
| 8 | 1.604 | 4.456 | 60.453 | 1.604 | 4.456 | 60.453 | 1.971 |
| 9 | 1.533 | 4.258 | 64.712 | 1.533 | 4.258 | 64.712 | 1.750 |
| 10 | 1.396 | 3.878 | 68.590 | 1.396 | 3.878 | 68.590 | 1.742 |
| 11 | 1.198 | 3.329 | 71.919 | 1.198 | 3.329 | 71.919 | 1.595 |
| 12 | 1.060 | 2.946 | 74.865 | 1.060 | 2.946 | 74.865 | 1.578 |
| 13 | 1.002 | 2.784 | 77.648 | 1.002 | 2.784 | 77.648 | 1.458 |
| 14 | .903 | 2.510 | 80.158 | - | - | - | - |
| 15 | .814 | 2.261 | 82.419 | - | - | - | - |
| 16 | .786 | 2.184 | 84.603 | - | - | - | - |
| 17 | .727 | 2.019 | 86.622 | - | - | - | - |
| 18 | .688 | 1.911 | 88.533 | - | - | - | - |
| 19 | .625 | 1.735 | 90.268 | - | - | - | - |
| 20 | .497 | 1.380 | 91.648 | - | - | - | - |
| 21 | .476 | 1.323 | 92.971 | - | - | - | - |
| 22 | .431 | 1.197 | 94.168 | - | - | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | .361 | 1.002 | 95.170 | - | - | - | - |
| 24 | .346 | .962 | 96.131 | - | - | - | - |
| 25 | .305 | .848 | 96.980 | - | - | - | - |
| 26 | .233 | .649 | 97.628 | - | - | - | - |
| 27 | .190 | .529 | 98.157 | - | - | - | - |
| 28 | .180 | .501 | 98.658 | - | - | - | - |
| 29 | .135 | .375 | 99.034 | - | - | - | - |
| 30 | .112 | .312 | 99.346 | - | - | - | - |
| 31 | .081 | .225 | 99.571 | - | - | - | - |
| 32 | .065 | .180 | 99.751 | - | - | - | - |
| 33 | .041 | .115 | 99.866 | - | - | - | - |
| 34 | .032 | .089 | 99.955 | - | - | - | - |
| 35 | .011 | .031 | 99.986 | - | - | - | - |
| 36 | .005 | .014 | 100.000 | - | - | - | - |

*Table 2 Extracted lean strategies*

| Sr. No. | Lean Strategies | Sources |
|---|---|---|
| S1. | Line improvement activity | (Salleh et al., 2012; Chai et al., 2012) |
| S2. | Ability to adjust capacity rapidly within a short time period | (Stecke& Kim, 1988; Ward &Duray, 2000) |
| S3. | Alternative supply chain networks | (Harland, 1996; Hugo &Pistikopoulos, 2005; Mohammaddust et al., 2017) |
| S4. | Focus on Market orientation | (Venkatraman&Ramanujam, 1987) |
| S5. | Development programs or past performance record | (Brown & Cousins, 2004) |
| S6. | Proper machine utilization | (Nordin et al., 2010) |
| S7. | Minimizing Work in progress | (Riezebos et al., 2009; Onyeocha et al., 2015) |
| S8. | Ability to provide innovation design | (Zhao et al., 2006; Le Dain et al., 2011) |
| S9. | Recycling of raw materials and defective parts | (Thierry et al., 1995; Wang et al., 2008) |
| S10 | Higher collaboration for better production planning | (Seifert, 2003; Kenne et al., 2007; Chinprateep&Boondiskulchok, 2010) |
| S11. | Monitoring the implementation schedules step by step | (Ballard & Howell, 1998; Guo et al., 2015; Soroush, 2015) |
| S12. | Training of employees to develop multi skills | (Wang et al., 2008; Heimerl&Kolisch, 2010) |
| S13. | Handling of appropriate variations in customer orders | (Anand& Ward, 2004) |

Now, after extracting the significant lean manufacturing strategies, a step by step implementation of ISM approach has been made as given below:

### 4.1 Structural self-interaction matrix (SSIM)

The SSIM is used to understand the related relationship between the diverse identified lean strategies in table 3 by making use of professional's view. The matrix delivers the pair-wise connection of each lean strategy. The signs [V, A, X and O] are applied for linking of lean strategies (a, b).

V - Strategy 'a' will assistance to enhance strategy 'b'

A -Strategy 'a' will assistance to enhance strategy 'b'

X -Strategy 'a' and 'b' will assistance to enhance each other

O - Strategy 'a' and 'b' are independent

*Table 3 SSIM lean strategies*

| S.no. | Lean Strategies | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1. | Line improvement activity | V | A | A | A | O | V | V | V | A | V | A | A | - |
| S2. | Ability to adjust capacity rapidly within a short time period | V | A | A | A | O | A | V | X | O | A | A | - | |
| S3. | Alternative supply chain networks | V | O | A | O | X | A | V | V | O | A | - | | |
| S4. | Focus on Market orientation | V | V | V | A | V | V | O | V | V | - | | | |
| S5. | Development programs or past performance record | V | A | V | X | V | V | V | V | - | | | | |
| S6. | Proper machine utilization | A | A | A | A | O | O | V | - | | | | | |
| S7. | Minimizing Work in progress | O | A | A | A | V | A | - | | | | | | |
| S8. | Ability to provide innovation design | X | A | A | A | O | - | | | | | | | |
| S9. | Recycling of raw materials and defective parts | A | A | O | O | - | | | | | | | | |
| S10 | Higher collaboration for better production | V | A | V | - | | | | | | | | | |

| | | | | |
|---|---|---|---|---|
| | planning | | | |
| S11. | Monitoring the implementation schedules step by step | X | A | - |
| S12. | Training of employees to develop multi skills | V | - | |
| S13. | Handling of appropriate variations in customer orders | - | | |

### 4.2 Reachability matrix

The formulation of the initial reachability matrix is the subsequent stage in ISM methodology. The transformation into initial reachability matrix as depicted in table 4 is obtained by the dual linking of the lean strategies in SSIM given in table 3 by means of binary system. The transformation is prepared with the assistance of the below mentioned rules:

When (a, b) in the set implies V, assign the value of (a, b) within the reachability matrix as 1 and assign the (b, a) value as 0.

When (a, b) in the set implies A, assign the value of (a, b) within the reachability matrix as 0 and assign the (b, a) value as 1.

When (a, b) in the set implies X, assign the value of (a, b) within the reachability matrix as 1 and assign the (b, a) value as 1.

When (a, b) in the set implies O, then assign the (a, b) result within the reachability matrix as 0 and assign the (b, a) value as 0.

*Table 4 Initial reachability matrix*

| Sr. no. | Lean Strategies | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1. | Line improvement activity | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| S2. | Ability to adjust capacity rapidly within a short time period | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| S3. | Alternative supply chain networks | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| S4. | Focus on Market orientation | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| S5. | Development programs or past | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | performance record | | | | | | | | | | | | | |
| S6. | Proper machine utilization | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| S7. | Minimizing Work in progress | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| S8. | Ability to provide innovation design | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| S9. | Recycling of raw materials and defective parts | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| S10 | Higher collaboration for better production planning | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| S11. | Monitoring the implementation schedules step by step | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| S12. | Training of employees to develop multi skills | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| S13. | Handling of appropriate variations in customer orders | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |

By applying the transitivity rule the initial matrix was converted into final matrix in table 5, which suggests that the lean strategy 'L' is interrelated to 'M' and 'M' is interrelated to 'N', it is considered that L will be interrelated to N. The set that indicates the transitivity is noticeable with the symbol (*).

*Table 5 Final reachability matrix*

| Sr. no. | Lean Strategies | 1 | 2 | 3 | 4 | …….. | 9 | 10 | 11 | 12 | 13 | S.P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1. | Line improvement activity | 1 | 1* | 1* | 1 | …….. | 1* | 0 | 1* | 1* | 1 | 12 |
| S2. | Ability to adjust capacity rapidly within a short time period | 1 | 1 | 0 | 1* | …….. | 1* | 0 | 1* | 0 | 1 | 9 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S3. | Alternative supply chain networks | 1 | 1 | 1 | 1* | …….. | 1 | 0 | 1* | 0 | 1 | 10 |
| S4. | Focus on Market orientation | 1* | 1 | 1 | 1 | …….. | 1 | 1* | 1 | 1 | 1 | 13 |
| S5. | Development programs or past performance record | 1 | 1* | 1* | 1* | …….. | 1 | 1 | 1 | 0 | 1 | 12 |
| S6. | Proper machine utilization | 1* | 1 | 0 | 0 | …….. | 1* | 0 | 0 | 0 | 1* | 6 |
| S7. | Minimizing Work in progress | 0 | 0 | 1* | 0 | …….. | 1 | 0 | 0 | 0 | 0 | 3 |
| S8. | Ability to provide innovation design | 1* | 1 | 1 | 0 | …….. | 1* | 0 | 1* | 0 | 1 | 9 |
| S9. | Recycling of raw materials and defective parts | 1* | 1* | 1 | 0 | …….. | 1 | 0 | 0 | 0 | 1* | 7 |
| S10 | Higher collaboration for better production planning | 1 | 1 | 1* | 1 | …….. | 1* | 1 | 1 | 1* | 1 | 13 |
| S11. | Monitoring the implementation schedules step by step | 1 | 1 | 1 | 1* | …….. | 1* | 0 | 1 | 0 | 1 | 10 |
| S12. | Training of employees to develop multi skills | 1 | 1 | 1* | 1* | …….. | 1 | 1 | 1 | 1 | 1 | 13 |
| S13. | Handling of appropriate variations in customer orders | 1* | 1* | 1* | 1* | …….. | 1 | 1* | 1 | 0 | 1 | 12 |
| | | 12 | 12 | 11 | 9 | …….. | 13 | 5 | 10 | 4 | 12 | |

### 4.3 Level partition

In order to filter out the reachability and antecedent sets, reachability matrix has been partitioned by applying the concept of level partition as shown in tables 6 and 7. In table 6, a complete process has been explained for level partition based on reachability and antecedent sets in respect of each filtered strategy.

However, in table 7, a complete summary of levels has been given. The reachability set includes the lean strategy itself along with lean strategies that it would affect while the antecedent set includes the lean strategy itself along with other lean strategies that may impact it. Then, different levels are obtained by the intersection for all lean strategies of these sets. The lean strategy whose reachability and antecedent set are identical, is placed in the uppermost level of the order. The uppermost level lean strategies are the ones that would not lead other lean strategies to overcome their own level in this order.

After identifying the topmost level of lean strategies, they are uninvolved in contemplation while the same procedure is reiterated to find out the successive levels. This method is applied till the level of each lean strategy is obtained. These levels play a major role in building the ISM model.

*Table 6 Level partition (Iteration I)*

| Lean Strategies | Reachability set | Antecedent set | Interaction | Level |
|---|---|---|---|---|
| S1. | 1,2,3,4,5,6,7,8,9,11,12,13 | 1,2,3,4,5,6,8,9,10,11,12,13 | 1,2,3,4,5,6,8,9,11,12,13 | - |
| S2. | 1,2,4,6,7,8,9,11,13 | 1,2,3,4,5,6,8,9,10,11,12,13 | 1,2,4,6,8,9,11,13 | - |
| S3. | 1,2,3,4,6,7,8,9,11,13 | 1,3,4,5,7,8,9,10,11,12,13 | 1,3,4,7,8,9,11,13 | - |
| S4. | 1,2,3,4,5,6,7,8,9,10,11,12,13 | 1,2,3,4,5,10,11,12,13 | 1,2,3,4,5,10,11,12,13 | - |
| S5. | 1,2,3,4,5,6,7,8,9,10,11,13 | 1,4,5,10,13 | 1,4,5,10,13 | - |
| S6. | 1,2,6,7,9,13 | 1,2,3,4,5,6,8,9,10,11,12,13 | 1,2,6,9,13 | - |
| S7. | 3,7,9 | 1,2,3,4,5,6,7,8,9,10,11,12,13 | 3,7,9 | I |
| S8. | 1,2,3,6,7,8,9,11,13 | 1,2,3,4,5,8,10,11,12,13 | 1,2,3,8,11,13 | - |
| S9. | 1,2,3,6,7,9,13 | 1,2,3,4,5,6,7,8,9,10,11,12,13 | 1,2,3,6,7,9,13 | I |
| S10 | 1,2,3,4,5,6,7,8,9,10,11,12,13 | 4,5,10,12,13 | 4,5,10,12,13 | - |
| S11. | 1,2,3,4,6,7,8,9,11,13 | 1,2,3,4,5,8,10,11,12,13 | 1,2,3,4,8,11,13 | - |
| S12. | 1,2,3,4,5,6,7,8,9,10,11,12,13 | 1,4,10,12 | 1,4,10,12 | - |
| S13. | 1,2,3,4,5,6,7,8,9,10,11,13 | 1,2,3,4,5,6,8,9,10,11,12,13 | 1,2,3,4,5,6,8,9,10,11,13 | - |

*Table 7 Level partition (Final Iteration)*

| Lean Strategies | Reachability set | Antecedent set | Interaction | Level |
|---|---|---|---|---|
| S1. | 1,2,3,4,5,6,8,11,12,13 | 1,2,3,4,5,6,8,10,11,12,13 | 1,2,3,4,5,6,8,11,12,13 | II |
| S2. | 1,2,4,6,8,11,13 | 1,2,3,4,5,6,8,10,11,12,13 | 1,2,4,6,8,11,13 | II |
| S3. | 3,4,8,11, | 3,4,5,8,10,11,12 | 3,4,8,11, | III |
| S4. | 4,5,10,12 | 4,5,10,12 | 4,5,10,12 | IV |
| S5. | 4,5,10, | 4,5,10 | 4,5,10 | IV |
| S6. | 1,2,6,13 | 1,2,3,4,5,6,8,10,11,12,13 | 1,2,6,13 | II |
| S7. | 3,7,9 | 1,2,3,4,5,6,7,8,9,10,11,12,13 | 3,7,9 | I |
| S8. | 8,11 | 3,4,5,8,10,11,12 | 8,11 | III |
| S9. | 1,2,3,6,7,9,13 | 1,2,3,4,5,6,7,8,9,10,11,12,13 | 1,2,3,6,7,9,13 | I |
| S10 | 4,5,10,12 | 4,5,10,12 | 4,5,10,12 | IV |
| S11. | 3,4,8,11 | 3,4,5,8,10,11,12 | 3,4,8,11 | III |
| S12. | 12 | 12 | 12 | V |
| S13. | 1,2,3,4,5,6,8,10,11,13 | 1,2,3,4,5,6,8,10,11,12,13 | 1,2,3,4,5,6,8,10,11,13 | II |

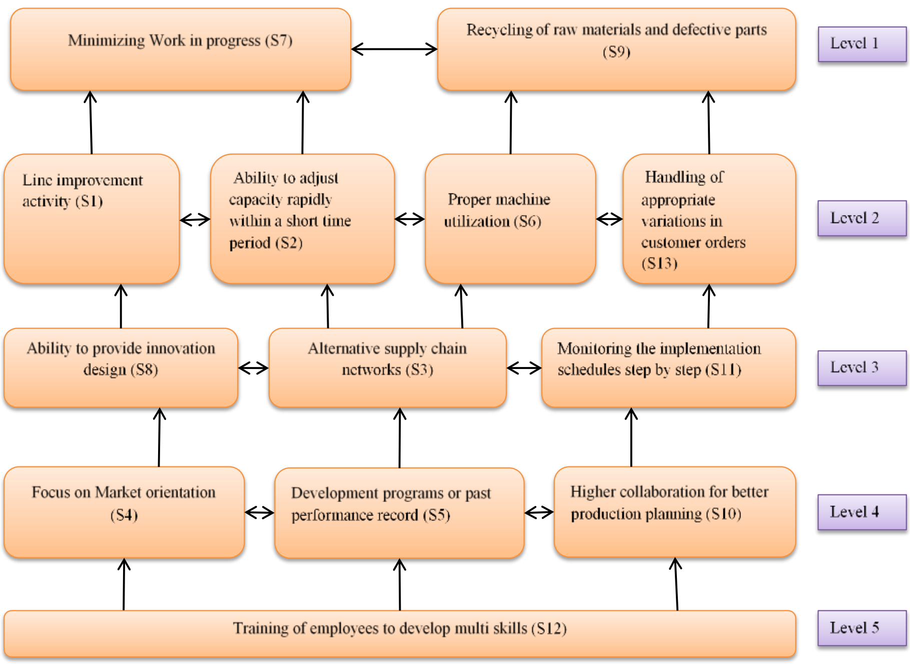



*Figure 3 Model based on ISM*

The above flow charts illustrated in figure 3 depicts the diverse lean strategies and their inter-dependence. In the flowchart, the adopted influential steps have been distributed into 5 levels for the progress of the organization. Training of employees to develop multi skills (S35) is most significant lean strategy which pushes all the former strategies which effect in positive incorporation of lean and every organization need to focus on this strategy. With continuous and systematic training, personnel become competent in new techniques that assist in building up several abilities which further help to steer the organization at higher level. The foundation of this ISM model is built up by level 5 strategies (S12).

Training of employees to develop multi skills (S12) escorts the three strategies at level 4 i.e. focus on market orientation (S4), development programs or past performance record (S5) and higher collaboration for better production planning (S10). These three strategies have solid connection among them based on the performance data of the past or improvement programs which plays a role in finding out the shortcomings of concluding products or new demands of consumers centered by concentrated on the inclination of the market. This would assist the manufacturing unit in teaming up with other personnel, hence enhancing productivity.

At level 3 strategies, alternative supply chain networks (S3), ability to provide innovation design (S8) and monitoring the implementation schedules step by step (S11) ushered by level 4. Regular training and Focusing on market orientation helps the employees to create the ability of innovative designing according to the demand that further come out to give alternative sully chain networks. This is also helps in monitoring the implementing schedules steps by steps. Level 2 drive the further four strategies i.e. line improvement activity (S1), ability to modify capacity quickly within a short time interval (S2), proper machine utilization (S6) and handling of appropriate variations in customer orders (S13).

Strategies at level 2 have very strong connectivity with each other. If there is proper machine utilization and improved line activity, it can create ability to adjust the capacity quickly within short period of time that helps to handle the variations in customers' orders.

Minimizing work in progress (S7) and recycling of raw materials and defective parts (S9) at first level directed by second level are the preferred products of the figures. Aforementioned two strategies acquiring the uppermost rank of this orderly representation make use of proper machine utilization and improved line activity results in minimizing work in process with minimal defective parts which gives desired best quality products and increases the productivity of the organization.

### 4.4 Fuzzy MICMAC analysis

MICMAC can be elaborated as "Matriced Impacts croises-multipication applique and classment" or in simple way it is define as "cross-impact matrix multiplication applied to classification" (Jain & Raj, 2016; Qureshi et al., 2008). This analysis involves the different steps as follows:

I: Creating the binary direct relationship matrix

II: Constructing the fuzzy direct reachability matrix

III: Producing the stabilized fuzzy MICMAC matrix

Here, fuzzy concept is used in order to consider the uncertainties or vagueness in the collected data useful for high accuracy in the decision results.

### 4.5 Creating the binary direct relationship matrix

To make the binary direct relationship matrix, it is required to transform the convectional MICMAC analysis into fuzzy MICMAC analysis using binary system (0 & 1). To make an analysis stronger through considering the uncertainty in the collected raw data, fuzzy set theory (Panchal & Kumar, 2014; Stojić et al., 2018; Chatterjee & Stević, 2019; Panchal et al., 2018; Panchal et al., 2019; Petrović et al.,2019; Đalić et al., 2020; Pająk, 2020; Kushwaha et al., 2020; Zavadskas et al., 2020) has been utilized. The binary direct relationship matrix is shown below in table 8.

*Table 8 Binary direct relationship matrix*

| Sr. no. | Lean Strategies | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | **D.P** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1. | Line improvement activity | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | **5** |
| S2. | Ability to adjust capacity rapidly within a short time period | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | **3** |
| S3. | Alternative supply chain networks | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | **6** |
| S4. | Focus on Market orientation | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | **9** |
| S5. | Development programs or past performance record | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | **8** |
| S6. | Proper machine utilization | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| S7. | Minimizing Work in progress | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| S8. | Ability to provide innovation design | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | **4** |
| S9. | Recycling of raw materials and defective parts | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| S10 | Higher collaboration | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | **9** |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | for better production planning | | | | | | | | | | | | | | |
| S11. | Monitoring the implementation schedules step by step | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | **7** |
| S12. | Training of employees to develop multi skills | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | **10** |
| S13. | Handling of appropriate variations in customer orders | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | **4** |
| | Dependence power | 6 | 7 | 4 | 2 | 3 | 9 | 9 | 7 | 7 | 2 | 5 | 1 | 9 | |

*Table 9 Possibility of numerical values of the reachability*

| Possibility of reachability | No | Very low | Low | Medium | High | Very high | Complete |
|---|---|---|---|---|---|---|---|
| Value | 0 | 0.1 | 0.3 | 0.5 | 0.7 | 0.9 | 1 |

### 4.6 Constructing the fuzzy direct reachability matrix

The values given in table 9 are made use in the binary direct relationship matrix for developing the fuzzy direct reachability matrix. The understanding of MICMAC analysis is augmented by making use of fuzzy theory which is why possibility of interaction is used to interpret the immediate connection among different lean strategies as represented in table 9. Therefore, fuzzy direct reachability is developed and as depicted in table 10.

*Table 10 Fuzzy direct reachability matrix*

| S.no. | Lean Strategies | 1 | 2 | 3 | 4 | ….. | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S1. | Line improvement activity | 0 | 0 | 0 | 0 | ….. | 0 | 0 | 0 | 0 | 0.1 |
| S2. | Ability to adjust capacity rapidly within a short time period | 0 | 0 | 0 | 0 | …… | 0 | 0 | 0 | 0 | 0.3 |
| S3. | Alternative supply chain networks | 0.3 | 0 | 0 | 0 | ….. | 0.9 | 0 | 0 | 0 | 0.3 |
| S4. | Focus on Market orientation | 0 | 0.9 | 0.7 | 0 | …… | 0.9 | 0 | 0.3 | 0 | 0.5 |
| S5. | Development | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0.1 |

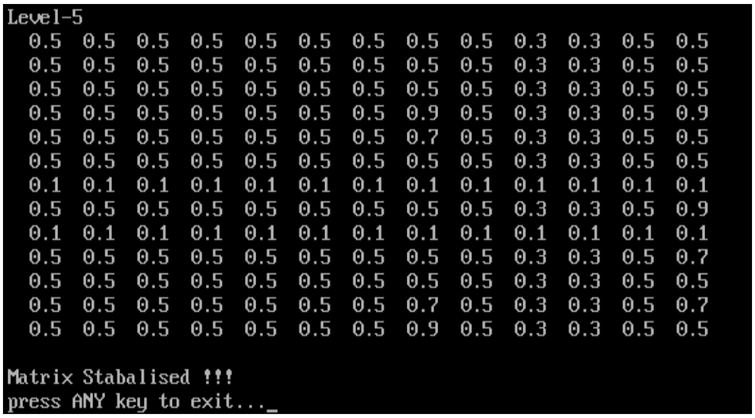
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | programs or past performance record | | | | | …… | | | | | |
| S6. | Proper machine utilization | 0 | 0 | 0 | 0 | …… | 0 | 0 | 0 | 0 | 0 |
| S7. | Minimizing Work in progress | 0 | 0 | 0 | 0 | …… | 0 | 0 | 0 | 0 | 0 |
| S8. | Ability to provide innovation design | 0 | 0 | 0 | 0 | …… | 0 | 0 | 0 | 0 | 0 |
| S9. | Recycling of raw materials and defective parts | 0 | 0 | 0 | 0 | …… | 0 | 0 | 0 | 0 | 0 |
| S10 | Higher collaboration for better production planning | 0.5 | 0.5 | 0 | 0 | ……. | 0 | 0 | 0.5 | 0 | 0.9 |
| S11. | Monitoring the implementation schedules step by step | 0.1 | 0.1 | 0 | 0 | …….. | 0 | 0 | 0 | 0 | 0 |
| S12. | Training of employees to develop multi skills | 0.5 | 0.5 | 0 | 0 | ……. | 0 | 0 | 0.5 | 0 | 0.7 |
| S13. | Handling of appropriate variations in customer orders | 0 | 0 | 0 | 0 | …….. | 0.3 | 0 | 0 | 0 | 0 |

The subset values are given in table10 is used as the base for constructing stabilized fuzzy MICMAC matrix. Multiplication of the obtained matrix is done many a times unless the orders of dependence and driving power become constant. With reference to the mentioned theory, the result obtained could be a fuzzy matrix, after the multiplication of two fuzzy (Kandasamy et al., 2007) interval values. The Following multiplication method is used to get the required result for multiplying of two fuzzy matrixes,

MN = Max {min (mij, nij)}

Where, M = [mij] and N = [nij] are two fuzzy matrices.

For solving the above equation, the program is written in the 'C' language to attain the accuracy. The result obtained is illustrated in figure 4 and the required stabilized fuzzy MICMAC matrix is given in table 11.



```
Level-5
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.3  0.3  0.5  0.5
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.3  0.3  0.5  0.5
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.3  0.3  0.5  0.5
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.9  0.5  0.3  0.3  0.5  0.9
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.7  0.5  0.3  0.3  0.5  0.5
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.3  0.3  0.5  0.5
  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.3  0.3  0.5  0.9
  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.3  0.3  0.5  0.7
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.3  0.3  0.5  0.5
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.7  0.5  0.3  0.3  0.5  0.7
  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.9  0.5  0.3  0.3  0.5  0.5

Matrix Stabalised !!!
press ANY key to exit..._
```

*Figure 4 Stabilized fuzzy MICMAC matrix*

*Table 11 Stabilized fuzzy MICMAC matrix*

| S.no. | Lean Strategies | 1 | 2 | 3 | 4 | …… | 9 | 10 | 11 | 12 | 13 | Driving power |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1. | Line improvement activity | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | **6.1** |
| S2. | Ability to adjust capacity rapidly within a short time period | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | **6.1** |
| S3. | Alternative supply chain networks | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | **6.1** |
| S4. | Focus on Market orientation | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.9 | **6.9** |
| S5. | Development programs or past performance record | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | **6.3** |
| S6. | Proper machine utilization | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | **6.1** |
| S7. | Minimizing Work in progress | 0.1 | 0.1 | 0.1 | 0.1 | …… | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | **1.3** |
| S8. | Ability to provide innovation design | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.9 | **6.5** |
| S9. | Recycling of raw materials | 0.1 | 0.1 | 0.1 | 0.1 | …… | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | **1.3** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | and defective parts | | | | | | | | | | | |
| S10 | Higher collaboration for better production planning | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.7 | **6.3** |
| S11. | Monitoring the implementation schedules step by step | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | **6.1** |
| S12. | Training of employees to develop multi skills | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.7 | **6.5** |
| S13. | Handling of appropriate variations in customer orders | 0.5 | 0.5 | 0.5 | 0.5 | …… | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | **6.5** |
| **Dependence power** | | **5.7** | **5.7** | **5.7** | **5.7** | **….** | **5.7** | **3.5** | **3.5** | **5.7** | **6.9** | |

Stabilized matrix as shown in table 11 is categorized into four cluster in accordance to driving power and dependence power. The summing up values of rows in the stabilized fuzzy MICMAC matrix is driving power and summing up values columns in the stabilized fuzzy MICMAC matrix is the dependence power. The cluster representation is shown in figure 5.

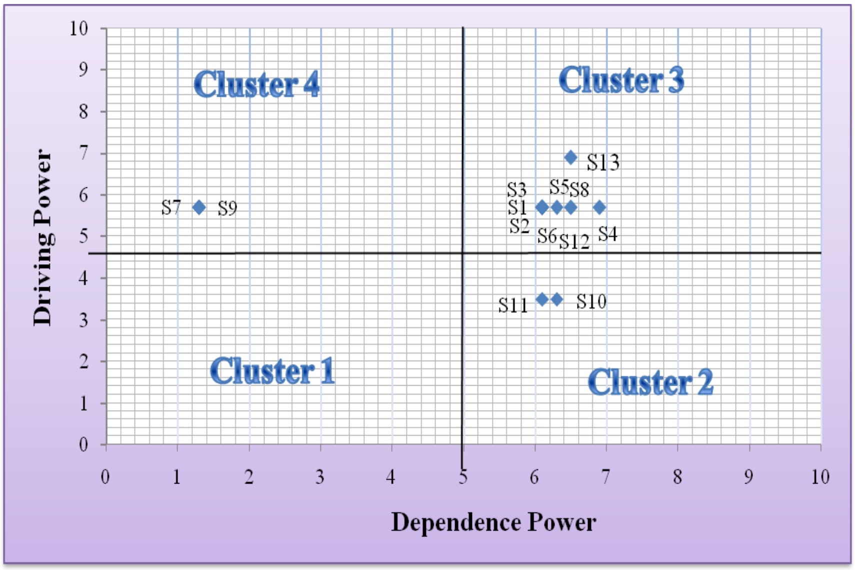



*Figure 5 Driving and dependence power graph*

**Cluster 1:** Lean strategies belonging to the particular group should have low driving and dependence power. Strategies in this group have no relation to each other. They are neither influence nor influenced by any others strategies. There is no lean strategy in our research that fall in this cluster. This is called autonomous cluster

**Cluster 2:** In this cluster, lean strategies are having low driving power and high dependence power. It characterizes lean strategies that are dependent on others strategies. The dependency of these lean strategies shows that they need all other lean strategies for the implementation of lean strategies into the system. Lean strategy (S7) minimizing work in progress and lean strategy (S9) recycling of raw materials and defective parts and are categorized in this cluster. This is called dependence cluster

**Cluster 3:** Lean strategies in this group are having very high driving power and high dependence power. This cluster denotes lean strategies which have very robust relation to each other's. Most of lean strategies in current research fall in this group. If there is a change in any lean strategy it will immediately affect the other lean strategy. Most of the lean strategies of present study fall in this cluster. Total eight strategies are categorized that are line improvement activity (S1), ability to adjust capacity quickly within a short time period (S2), alternative supply chain networks (S3), focus on Market orientation (S4), development programs or past performance record (S5), proper machine utilization (S6), ability to provide innovation design (S8), training of employees to develop multi skills (S12) and handling of appropriate variations in customer orders (S13). This is called linkage cluster.

**Cluster 4:** Lean strategies belonging to this group have low dependence power but very high driving power. Lean strategy which are categorized in this group are higher collaboration for better production planning (S10) and monitoring the implementation schedules step by step (S11). This is called Independent Cluster.

## 5. Managerial implications of the work

To prevail over the various tasks that emerge during production time and to improve the efficiency of their organization, managers require flexible attitudes to take the worthwhile decision for the growth of organization. The current research reveals that manager is required to emphasize on diverse lean strategies liable on the condition at different level. Training of employees is the primary need of the organization which accelerates the others strategies effectively in every field. Apart from this strategy, managers need to focus on secondary strategies at different level also as illustrated in figure 2. Driving and dependence graph illustrated in figure 3 would help the managers to decide whether the applied strategies are driving in nature or dependent on others. Most of strategies fall in cluster 3 managers have to focus more on this category. Strategies in this category are very crucial for application of lean manufacturing in the organization. Also, each and every strategy serves its role in the performance of the organization at its level. Therefore, this study helps the managers for implementation of various lean strategies into the organization.

## 6. Conclusion

It is understood that no single strategy is enough for implementation of lean manufacturing for enhancement of the efficiency organization. After factor analysis out of thirty-six lean strategies thirteen were extracted using software SPSS 21 and analyzed by structural modeling and then used to construct the ISM based model which helps to understand the direct relationship among various lean strategies. “Training of employees to develop multi skills(S12)” has been identified as the most crucial strategy which drives all the other strategies for the success of lean. Minimizing Work in progress (S7) and recycling of raw material and defective parts (S9) were level one, strategies whose success is dependent on other factors. Apart from the relationship among various lean strategies, it was also essential to express the role of individual strategy also. It was observed that most of the selected strategies have very high driving power and dependence power as well. No lean strategy was identified which fall in the autonomous cluster. Higher collaboration for better production planning (S10) and monitoring the implementation schedules step by step (S11) have been identified as the independent strategies which have high driving power and low dependence power. Also, minimizing work in progress (S7) and recycling of raw materials and defective parts (S9) were categorized in dependence cluster as they have low driving power and high dependence power. Organization across the globe now wants to make their system more define for every aspect. The present research contribution gives the optimistic correlation between different lean strategies to maintain their organization systematically. The present research assists the managers or industrialists in decision making for the implication of particular lean strategy during the production. The outcomes of this research may also be helpful for managers to comprehend the indirect and direct relationship among various lean strategies in order to provide a path to improve the efficiency of their enterprise in this competitive market. As an advantage of lean system in manufacturing organization, it is most valuable to identify and asses the importance of strategies related to lean system but it is not easy or feasible to implement the all strategies at a time in any industry or organization. For the same, a need arises to explore the strategies based on their dependence and driving behavior in order to implement and improve the lean manufacturing system of an organization. By keeping this view in mind, this study has been performed.

### 6.1 Limitations and future scope of the work

In this study, initially thirty-six lean strategies were identified on the basis of literature review; however, thirteen lean strategies have been extracted by using factor analysis. In ISM approach, there is no restriction in consideration on numbers of lean strategies, therefore more numbers of lean strategies can also be considered. Moreover, as the numbers of lean strategies increases, ISM model will become more complex. To drive the analysis, data have been gathered only from the automobiles industries situated at Delhi NCR. In future, data can also be gathered from the automobile industries situated at different locations of India and comprehensive study can also be implemented. To compare the outcomes of present research, the other multi-faceted decision building approaches like Fuzzy DEMATEL and SEM can be considered.

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