ASSESSMENT OF DRIVERS TO IMPLEMENT LEAN MANUFACTURING IN INDIAN SMES USING INTUITIONISTIC FUZZY BASED TOPSIS APPROACH

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Abstract: Small and medium enterprises (SMEs) in the manufacturing sector face many problems related to quality, cost, flexibility and delivery time owing to increased competition in the current globalized market economy. Lean manufacturing (LM) has been proposed as a solution to some of these issues to improve the overall performance. There are multiple factors that act as motivation to implement LM. This study considers 18 drivers in the adoption of LM, which have been identified on the basis of extensive literature reviews and opinion of the experts. The ranking of drivers in the context of Indian SMEs has been accomplished by utilizing IF-TOPSIS approach. The results reveal that "reduce cost", "improve quality", "improve labor productivity", "reduce inventory" and "shortened production lead time" are the most significant drivers. This study provides important insight to industry and government personnel's to focus on essential drivers to facilitate proper and effective execution of LM.
Key words: Lean manufacturing, drivers, IF-TOPSIS, SMEs, India.

1. INTRODUCTION

Small and medium enterprises (SMEs) play an important role in the manufacturing sector globally in terms of employment generation and volume production**.** In the contemporary dynamic global marketplace, SMEs face the challenge of rapidly growing competition, emerging technologies and ever-changing customer behavior. Faster adoption of new emerging manufacturing technology over the outdated or existing manufacturing practice is one of the major challenges faced by SMEs. The other is fast changing customer behavior whereby they demand more innovative and better quality products at a lesser price with very short period of time. In order to survive in the face of these challenges posed by global competitors in the fast changing marketplace, the organizations need to switch to lean manufacturing (LM) strategy over traditional manufacturing (Sahoo *et al.*,2008). The term "*lean production*" was first used in 1988 by John Krafcik in his article *"Triumph of the lean production system"* Krafcik (1988). Later the term was popularized by Womack and Jones in their book *"The Machine That Changed the World"* (Womack *et al.*, 1990). LM is a new manufacturing paradigm which focuses on continuous elimination of nine deadly wastes within the organization and across the supply chain (Tice *et al.*, 2005). The objective of LM is to provide a proper channel of producing high quality products with limited resources such as equipment, manpower, space and time to meet the customer demand. According to Khadem *et al.*, (2008**)** *"Lean production is an integrated approach to manufacturing of products (service) with the purpose of achieving superior quality, timely delivery and competitive cost leading to customer satisfaction".* SMEs in India have emerged as a vibrant and dynamic sector of the Indian economy over the last few decades. They play a crucial role in providing large employment opportunities at a comparatively lower capital cost and can be set up even in rural areas. The 48 million SMEs in India is growing at an annualized rate of 4.5% over the last five years and provide 40% employment of the total workforce and contribute 45% of manufacturing sector output which amounts to only 17% of GDP (Vyas *et al.*, 2015). However, in near-term, the Indian SMEs can grow and increase their contribution in GDP with reforms and adoption of new technologies. In India, SMEs in manufacturing sector currently plagued with problems of high inventory, poor housekeeping, low manpower productivity, high scrap, global competition, un-standardized operation, insufficient skilled manpower, high product development time and turbulent and uncertain market scenario which restrict their growth. To survive and flourish in the global market, SMEs needs to address these issues by adopting innovative approaches such as LM in their operations and supply chain. Indian SMEs resists change as they fear new technology adoption is an expensive and a never ending process because of fast turnover in technology. SMEs managers tend to view new technology as an expense rather than as a strategic investment. Hence, implementation of any new manufacturing strategy, particularly in small and medium manufacturing sector, needs strong motivating factors which can force the management of SMEs to adopt the new manufacturing strategy. For proper and effective implementation of LM strategy, management of SMEs must understand the key drivers that motivate the adoption of LM. So, a suitable methodology is required to facilitate the industries to identify the key drivers. This study used integrated intuitionistic fuzzy-technique for order of preference by similarity to ideal solution (IF-TOPSIS, Technique for Order of Preference by Similarity to Ideal Solution) approach to rank the key drivers. IF-TOPSIS provide complete tool to handle the vagueness and uncertainty in complex environments by measuring the inherent ambiguity of decision maker's judgment in multi criteria decision making (MCDM) area. Based on the literature review and expert opinion, 18 drivers are extracted that motivate the implementation of LM in SMEs at Indian scenario. The uniqueness of this research work is that it analyzes the qualitative data while utilizing integrated IF-TOPSIS methodology to rank the drivers that influence implementation of LM in Indian SMEs.

2. LITERATURE REVIEW

In the past, plenty of research work has been conducted on methodology, case study, framework, tools/techniques and benefits of LM system. Moreover, the earlier researches which have been carried out to find the driving factors that influence LM implementation in the manufacturing industry through survey questionnaires are limited in number. Jasti *et al.,* (2016) identified the driving factors through questionnaire survey, in which 71.67% respondents were from large scale industry; found that improving customer satisfaction was the prime influencing factor in the implementation of lean philosophy in Indian manufacturing industries. Ghosh (2012) examined the status of lean implementation and identified three important drivers i.e. first-pass correct output, reduction of lead time and productivity improvement which aid in adoption of lean in Indian large scale manufacturing firms. Kumar *et al.,* (2013) recognized 18 variables to implement LM in Indian automobile sectors and developed a structural model while using interpretive structural model (ISM). Zhou (2012) found that cost reduction, competitiveness, plant utilization and improvement in profit margin were the prime reasons to adopt LM in US based SMEs. Attri *et al.,* (2013) identified 10 enablers and developed a hierarchical model in implementation of total productive maintenance, while employing ISM technique. Bhasin (2012) carried out a survey of 68 British manufacturing industries and concluded that improve performance, competitive pressure, create team spirit and customer pressure were the top most reasons to adopt LM. Upadhye *et al.,* (2011) identified the driving forces and critical issues in implementation of LM by using ISM methodology. Mishrikoti *et al.,* (2011) explored the driving factors and found that equipment utilization and scrap reduction were the most significant driving forces to implement LM in small firms. Singh *et al.,* (2010) examined and categorized the factors into five different categories that force the organization to adopt lean system. Nordin *et al.,* (2010) investigated both drivers and barriers in implementation of LM in Malaysian automotive organizations. Hallgren *et al.,* (2009) identified internal and external factors that drive lean and agile manufacturing and analyzed the impact on operational performance while using structural equation modeling technique. It becomes quite evident from the review of past literatures that the quantum of research work to identify and rank the drivers from three different perspectives viz. industry, academics and government to implement LM in small and medium manufacturing sector at Indian scenario through MCDM approach is not in proportion at all with the incredible growth in the industrial activities in this sector. Therefore, the present study attempts to bridge the gap by identifying the common drivers of LM and by evaluating its rank. The list of 18 selected drivers of LM adoption is provided in table 1.

The some highlights of this study are listed below:

-Identify the common drivers of LM through an extensive literature review and experts suggestions;

-Proposed a framework to rank LM drivers in small and medium manufacturing industries at Indian scenario using IF-TOPSIS;

-Validate the obtained results through feedback from government, industry and academic experts and compare with the existing literature.

3. APPLICATION OF PROPOSED FRAMEWORK

The framework of the study to rank 18 drivers of LM implementation in Indian SMEs is exhibited in Figure 1. The framework broadly consists of three stages. The first stage comprises of identification of drivers on the basis of published literature and suggestions from the experts. In the next stage, IF-TOPSIS method is applied to rank the drivers based on the opinions of decision makers from three different domains viz. industry, academics and government. In the last stage the results obtained are validated through the past literature and feedback of decision makers. The linguistic scale and intuionistic fuzzy rating for alternative and criteria are shown in Table2.

Stage 1: Identification of common drivers of lean manufacturing.

In the first stage of the proposed model is to gather various drivers of LM through existing literature and suggestions from experts'. A systematic literature review technique is followed and the time period of search in electronic database such as "Google Scholar", "Web of Science", "Scopus" etc., was from 1988 to 2016 with search terms that contained conjunction of exact word and more characters like "lean manufacturing", "lean production", "lean thinking", "Toyota production system", "lean-agile",

Table 1. Common drivers of Lean Manufacturing

S. No.	List of drivers	Notations	References
1	Competitiveness	D1	Zhou (2012), (Hallgren *et al.*, 2009), (Michael *et al.*, 2000)
2	Improve man and machine utilizations	D2	Ghosh (2012), (Vinodh *et al.*, 2010), (Jeyaraj *et al.*, 2013), (Mishrikoti *et al.*, 2011)
3	Standardize the operations	D3	(Zuting *et al.*, 2014), (Cook *et al.*, 1996), (Sohal *et al.*, 1994),
4	Improve quality	D4	(Venkataraman *et al.*, 2014), Zhou (2012), (Mishrikoti *et al.*, 2011)
5	Develop team sprit between employees	D5	Bhasin (2012)
6	Shortened production lead time	D6	(Jeyaraj *et al.*, 2013), (Vinodh *et al.*, 2010)
7	Increase flexibility	D7	Zhou (2012), (Jasti *et al.*, 2016), (Hallgren *et al.*, 2009)
8	Improve labor productivity	D8	(Staats *et al.*, 2011), Ghosh (2012)
9	Employ world best practices	D9	(Jasti *et al.*, 2016)
10	Increase market share	D10	Zhou (2012), (Jasti *et al.*, 2016)
11	Skill development	D11	(Singh *et al.*, 2010), (Panizzolo *et al.*, 2012),
12	Improve customer satisfaction	D12	(Jasti *et al.*, 2016), (Singh *et al.*, 2010), (Nordin *et al.*, 2010), (Mishrikoti *et al.*, 2011)
13	Establish better vendor relationship	D13	(Mishrikoti *et al.*, 2011), (Zhou 2012),
14	Development of key performance indicators	D14	(Jasti *et al.*, 2016), **(**Khadem *et al.*, 2008**)**
15	Reduce cost	D15	(Mishrikoti *et al.*, 2011), (Zhou 2012)
16	Reduce new product development time	D16	(Shepherd *et al.*, 2000), (Schmidt *et al.*, 2009)
17	Reduce inventory	D17	Zhou (2012), (Singh *et al.*, 2010), (Singh *et al.*, 2011)
18	Create safe and better working environment	D18	Bhasin (2012), Goldstein (2001)

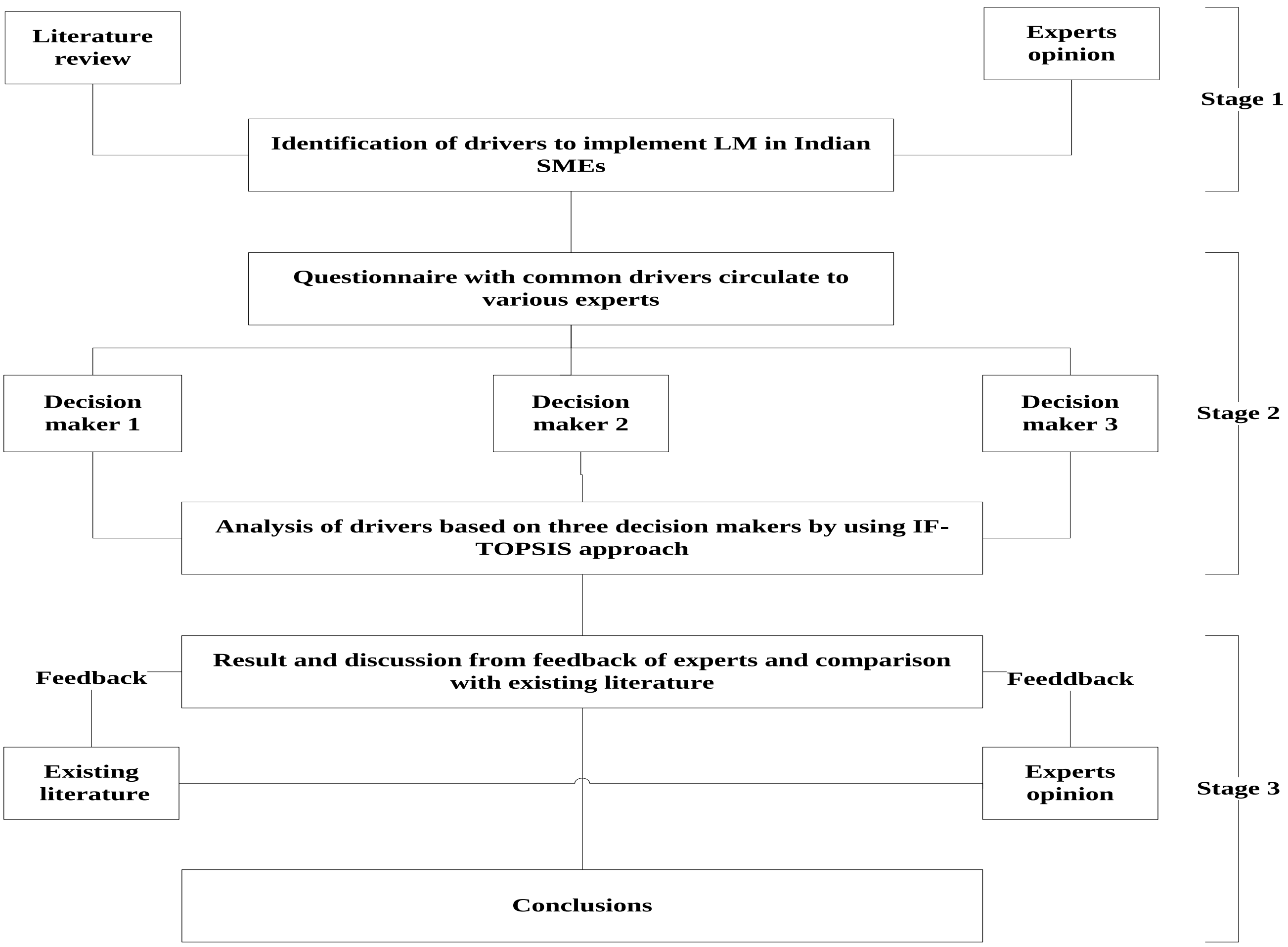

Fig. 1. Framework of the study

1988 to 2016 with search terms that contained conjunction of exact word and more characters like "drivers", "critical success factors", "SMEs" and so on. After several rounds of discussions and content verification with experts, 18 common drivers are selected.

Table 2. Linguistic scale and intuionistic fuzzy rating for alternative and criteria

Linguistic terms	Intuitionistic Fuzzy numbers
Unimportant (U)	(0.10,0.90,0.00)
Least important (LI)	(0.35,0.60,0.05)
Important (I)	(0.50,0.45,0.05)
Very important (VI)	(0.75,0.20,0.05)
Most important (MI)	(0.90,0.10,0.00)

Stage 2: Application of IF-TOPSIS Approach

In this stage, common drivers of LM are analyzed by using IF-TOPSIS approach, which are identified in the previous stage. TOPSIS is a simple and very useful technique to solve MCDM problems, which was developed by Hwang in the year 1981 (Hwang *et al.*, 1981). It is based on idea that optimal alternative should have the shortest distance from positive ideal solution (PIS) and have a longest distance from negative ideal solution (NIS). TOPSIS method utilizes both distances from PIS and NIS simultaneous to rank the order of preference according to descending order of the relative closeness coefficient. Due to the increased complexity in decision making process, fuzzy sets are generally used by decision makers to embody the uncertainty and ambiguity**.** An intutionistic fuzzy set (IFS) proposed by Atanassov in 1986 is an extended version of classical fuzzy set, which handles vagueness very well manner in uncertain environments (Atanassov *et al.,* 1986). They have been successfully applied in different field such as decision making, medical diagnosis, pattern recognition etc.

Consider X is a finite set. Then IFS A in X is written as:

$A=\{(\chi,\mu_A(\chi),\upsilon_A(\chi))\, x\in X\}$

Where, $\mu_A(\chi): X\rightarrow[0,1]$ are membership function and $\upsilon_A(\chi): X\rightarrow[0,1]$ non-memberships function, such that

$$0\le\mu_A(\chi)+\upsilon_A(A)\le 1, \mathrm{x}\in X \qquad (1)$$

The third parameter $\pi_A(x)$ is known as the intutionistic fuzzy index and show the hesitation level of $x\in X$ to A and $0\le\pi_A(x)\le 1, x\in X$ which are determine as follows:

$$\pi_A(\chi)=1-\mu_A(\chi)-\upsilon_A(\chi) \qquad (2)$$

If the $\pi_A(x)$ is small, knowledge about x is more certain. If $\pi_A(x)$ is large, knowledge about x is more uncertain.

If A and B is IFSs of the set x, then the multiplication operator is defined as:

$$A\otimes B=\{\mu_A(x).\mu_B(x),\upsilon_A(x)+\upsilon_B(x)-\upsilon_A(x).\upsilon_B(x)|x\in X\} \qquad (3)$$

The IF-TOPSIS approach involves the following steps (Boran *et al.,* 2009):

Step 1: Assignment of rating to the alternatives (Drivers) and criteria (Perspective)

Let us assume that $A=A_1,A_2,A_{3,}...A_m$ be a set of possible alternatives, $X=X_1,X_2,X_{3,}...X_n$ be a set of evaluation criteria and the weight of criteria are denoted by $w_j=w_1,w_2,w_{3,}...w_n$. The performance ratings of each decision maker for each alternative with respect to criteria are denoted , which is based on position, working experience and education qualification. The present study deals with 18 alternatives and three criteria. The linguistic assessment of alternatives and criteria by the decision makers are shown in Table 3 and Table 4 respectively.

Table 3. Linguistic assessment of alternatives

Notations	Industry	Academics	Government
D1	MI	VI	VI
D2	VI	I	MI
D3	VI	I	I
D4	MI	MI	VI
D5	I	I	LI
D6	MI	I	MI
D7	VI	VI	I
D8	VI	VI	MI
D9	I	I	VI
D10	I	VI	MI
D11	I	I	I
D12	MI	VI	I
D13	I	VI	VI
D14	I	LI	I
D15	MI	VI	MI
D16	VI	LI	I
D17	I	MI	VI
D18	I	LI	VI

Table 4. Linguistic assessment of the criteria

Criteria	DM1	DM2	DM3
Industry perspective (C1)	MI	MI	VI
Academics perspective (C2)	VI	VI	I
Government perspective (C3)	I	VI	MI

Step 2: Compute the weight of decision makers

Let $D_k=[\mu_k,\nu_k,\pi_k]$ be an intuitionistic fuzzy number for rating of k^{th} decision makers. Then the weight of k^{th} decision makers is determined by equation (4) and is shown in Table 5.

$$\lambda_k = \frac{\left(\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k+\nu_k}\right)\right)}{\sum_{k=1}^{l}\left(\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k+\nu_k}\right)\right)} \quad (4)$$

Where, $k = 1,2,3,...l$

Table 5. The importance of decision makers and their weights

	DM1	DM2	DM3
Linguistic terms	MI	I	VI
Intuitionistic Fuzzy numbers	(0.90,0.10,0.00)	(0.50,0.45,0.05)	(0.75,0.20,0.05)
Crisp weights	0.406	0.238	0.356

Step 3: Compute IF decision matrix

The intutionistic fuzzy decision matrix (R) for the alternatives can be defined as follows, which is shown in Table 6.

$$R=\begin{bmatrix} \mu_{A_1}(x_1),\upsilon_{A_1}(x_1),\pi_{A_1}(x_1) & \mu_{A_1}(x_2),\upsilon_{A_1}(x_2),\pi_{A_1}(x_2) & \cdots & \mu_{A_1}(x_n),\upsilon_{A_1}(x_n),\pi_{A_1}(x_n) \\ \mu_{A_2}(x_1),\upsilon_{A_2}(x_1),\pi_{A_2}(x_1) & \mu_{A_2}(x_2),\upsilon_{A_2}(x_2),\pi_{A_2}(x_2) & \cdots & \mu_{A_2}(x_n),\upsilon_{A_2}(x_n),\pi_{A_2}(x_n) \\ \vdots & \vdots & \ddots & \vdots \\ \mu_{A_m}(x_1),\upsilon_{A_m}(x_1),\pi_{A_m}(x_1) & \mu_{A_m}(x_2),\upsilon_{A_m}(x_2),\pi_{A_m}(x_2) & \cdots & \mu_{A_m}(x_n),\upsilon_{A_m}(x_n),\pi_{A_m}(x_n) \end{bmatrix}$$

Step 4: Compute aggregate weight of criteria

All criteria may not be give equal importance. Let $w_j^k = \left[\mu_j^k, \nu_j^k, \pi_j^k\right]$ be an IF number assigned to criteria x_j by the k^{th} decision maker. Then the aggregate weight of the criteria are obtained by using intuitionistic fuzzy weighted averaging (IFWA) operator from the equation (5), which is shown in Table 7.

$$w_j = IFWA_\lambda\left(w_j^{(1)}, w_j^{(2)}, ..., w_j^{(l)}\right)$$

$$w_j = \lambda_1 w_j^{(1)} \oplus \lambda_2 w_j^{(2)} \oplus \lambda_3 w_j^{(3)} \oplus .... \oplus \lambda_l w_j^{(l)}$$

$$w_j = \left[1-\prod_{k=1}^{l}\left(1-\mu_j^{(k)}\right)^{\lambda_k}, \prod_{k=1}^{l}\left(\nu_j^{(k)}\right), \prod_{k=1}^{l}\left(1-\mu_j^{(k)}\right)^{\lambda_k} - \prod_{k=1}^{l}\left(\nu_j^{(k)}\right)^{\lambda_k}\right] \quad (5)$$

Where, $j = 1,2,3,...,n$

Step 6: Construct aggregated weighted intuitionistic fuzzy decision matrix

After construction of intuitionistic fuzzy decision matrix and calculation of aggregate weight criteria, the aggregated weighted intuitionistic fuzzy decision matrix (R') is obtained by equation (6) and (7), which is shown in Table 8.

$$\pi_{Ai.W}(x) = 1-\nu_{Ai}(x)-\nu_w(x)-\mu_{Ai}(x)\cdot\mu_w(x)+\nu_{Ai}(x)\cdot\nu_w(x) \quad (6)$$

$$R \otimes W = \left\{\left\langle x, \mu_{Ai}(x).\mu_W(x), \upsilon_{Ai}(x)+\upsilon_W(x)-\upsilon_{Ai}(x).\upsilon_W(x)\right\rangle \mid x \in X\right\} \quad (7)$$

Step 7: Compute the intuitionistic fuzzy positive ideal solution (IFPIS) and intuitionistic fuzzy negative ideal solutions (IFNIS) by equation (8) and (9).

$$A^- = \left(\tilde{r}_1^-, \tilde{r}_2^-, \tilde{r}_3^-, ..., \tilde{r}_n^-\right) = (\mu^-_{A_i.W}(x_j), \nu^-_{A_i.W}(x_j), \pi^-_{A_i.W}(x_j)), j = 1,2,.....n \quad (8)$$

$$A^* = \left(\tilde{r}_1^*, \tilde{r}_2^*, \tilde{r}_3^*, ..., \tilde{r}_n^*\right) = (\mu^*_{A_i.W}(x_j), \nu^*_{A_i.W}(x_j), \pi^*_{A_i.W}(x_j)), j = 1,2,.....n \quad (9)$$

Where,

$$\mu^*_{A_i.W}(x_j) = \{\max_i \mu_{A_i.W}(x_j)\ j = 1,2,...,n\}$$

$$\nu^*_{A_i.W}(x_j) = \{\min_i \mu_{A_i.W}(x_j)\ j = 1,2,...,n\}$$

$$\nu^-_{A_i.W}(x_j) = \{\max_i \mu_{A_i.W}(x_j)\ j = 1,2,...,n\}$$

$$\mu^-_{A_i.W}(x_j) = \{\min_i \mu_{A_i.W}(x_j)\ j = 1,2,...,n\}$$

Step 8: Calculate distance between the alternatives and the IFPIS as well as the IFNIS, respectively by equation (10) and (11).

$$S^* = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}(\mu_{A_i.W}(x_j)-\mu_{A_i^*.W}(x_j))^2 + (\nu_{A_i.W}(x_j)-\nu_{A_i^*.W}(x_j))^2 + (\pi_{A_i.W}(x_j)-\pi_{A_i^*.W}(x_j))^2} \quad (10)$$

$$S^- = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}(\mu_{A_i.W}(x_j)-\mu_{A^-_i.W}(x_j))^2 + (\nu_{A_i.W}(x_j)-\nu_{A^-_i.W}(x_j))^2 + (\pi_{A_i.W}(x_j)-\pi_{A^-_i.W}(x_j))^2} \quad (11)$$

Step 5: Compute the relative closeness coefficient of each alternative with respect to IFPIS by using equation (12).

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-} \quad (12)$$

Where, $0 \le C_{i^*} \le 1 (i = 0,1,2,....,m)$

Step 9: Rank of alternatives is determined according to descending order of relative closeness coefficient C_i^* which is shown in Table 9.

Stage 3: Results validation

The obtained results are discussed with the decision makers to check the reliability of the outcomes. After discussion with experts, no significant differences are found and the results are greatly corroborated with the opinion of the experts. Finally, the results of this study are also validated with existing literature.

Table 6. The intutionistic fuzzy decision matrix

Notations	Industry	Academics	Government
D1	(0.90,0.10,0.00)	(0.75,0.20,0.05)	(0.75,0.20,0.05)
D2	(0.75,0.20,0.05)	(0.75,0.20,0.05)	(0.90,0.10,0.00)
D3	(0.75,0.20,0.05)	(0.50,0.45,0.05)	(0.50,0.45,0.05)
D4	(0.90,0.10,0.00)	(0.90,0.10,0.00)	(0.90,0.10,0.00)
D5	(0.50,0.45,0.05)	(0.50,0.45,0.05)	(0.35,0.60,0.05)
D6	(0.90,0.10,0.00)	(0.75,0.20,0.05)	(0.90,0.10,0.00)
D7	(0.75,0.20,0.05)	(0.75,0.20,0.05)	(0.50,0.45,0.05)
D8	(0.75,0.20,0.05)	(0.75,0.20,0.05)	(0.90,0.10,0.00)
D9	(0.50,0.45,0.05)	(0.50,0.45,0.05)	(0.75,0.20,0.05)
D10	(0.75,0.20,0.05)	(0.75,0.20,0.05)	(0.90,0.10,0.00)
D11	(0.50,0.45,0.05)	(0.50,0.45,0.05)	(0.50,0.45,0.05)
D12	(0.75,0.20,0.05)	(0.75,0.20,0.05)	(0.90,0.10,0.00)
D13	(0.50,0.45,0.05)	(0.50,0.45,0.05)	(0.75,0.20,0.05)
D14	(0.50,0.45,0.05)	(0.35,0.60,0.05)	(0.50,0.45,0.05)
D15	(0.90,0.10,0.00)	(0.90,0.10,0.00)	(0.90,0.10,0.00)
D16	(0.50,0.45,0.05)	(0.35,0.60,0.05)	(0.50,0.45,0.05)
D17	(0.50,0.45,0.05)	(0.75,0.20,0.05)	(0.90,0.10,0.00)
D18	(0.50,0.45,0.05)	(0.35,0.60,0.05)	(0.75,0.20,0.05)

Table 7. The aggregate intuitionstic fuzzy weight of criteria

Criteria	DM1	DM2	DM3	Aggregate weight
C1	(0.90,0.10,0.00)	(0.90,0.10,0.00)	(0.75,0.20,0.05)	(0.8614,0.1279,0.0105)
C2	(0.75,0.20,0.05)	(0.75,0.20,0.05)	(0.50,0.45,0.05)	(0.6800,0.2669,0.0529)
C3	(0.50,0.45,0.05)	(0.75,0.20,0.05)	(0.90,0.10,0.00)	(0.7609,0.2170,0.0220)

Table 8. The aggregate weighted intutionistic fuzzy decision matrix

S. No.	Notations	Industry	Expert	Government
1	D1	(0.7752,0.2151,0.0096)	(0.5100,0.4135,0.0764)	(0.5706,0.3736,0.0557)
2	D2	(0.6460,0.3023,0.0516)	(0.3400,0.5989,0.0632)	(0.6848,0.2953,0.1990)
3	D3	(0.6460,0.3023,0.0516)	(0.3400,0.5989,0.0632)	(0.3804,0.5693,0.0502)
4	D4	(0.7752,0.2151,0.0096)	(0.6120,0.3402,0.0477)	(0.5706,0.3736,0.0557)
5	D5	(0.4307,0.5203,0.0489)	(0.3400,0.5989,0.0632)	(0.2663,0.6868,0.0468)
6	D6	(0.7752,0.2151,0.0096)	(0.3400,0.5989,0.0632)	(0.6848,0.2953,0.1990)
7	D7	(0.6460,0.3023,0.0516)	(0.5100,0.4135,0.0764)	(0.3804,0.5693,0.0502)
8	D8	(0.6460,0.3023,0.0516)	(0.5100,0.4135,0.0764)	(0.6848,0.2953,0.1990)
9	D9	(0.4307,0.5203,0.0489)	(0.3400,0.5989,0.0632)	(0.5706,0.3736,0.0557)
10	D10	(0.4307,0.5203,0.0489)	(0.5100,0.4135,0.0764)	(0.6848,0.2953,0.1990)
11	D11	(0.4307,0.5203,0.0489)	(0.3400,0.5989,0.0632)	(0.3804,0.5693,0.0502)
12	D12	(0.7752,0.2151,0.0096)	(0.5100,0.4135,0.0764)	(0.3804,0.5693,0.0502)
13	D13	(0.4307,0.5203,0.0489)	(0.5100,0.4135,0.0764)	(0.5706,0.3736,0.0557)
14	D14	(0.4307,0.5203,0.0489)	(0.2380,0.7067,0.0552)	(0.3804,0.5693,0.0502)
15	D15	(0.7752,0.2151,0.0096)	(0.5100,0.4135,0.0764)	(0.6848,0.2953,0.1990)
16	D16	(0.6460,0.3023,0.0516)	(0.2380,0.7067,0.0552)	(0.3804,0.5693,0.0502)
17	D17	(0.4307,0.5203,0.0489)	(0.6120,0.3402,0.0477)	(0.5706,0.3736,0.0557)
18	D18	(0.4307,0.5203,0.0489)	(0.2380,0.7067,0.0552)	(0.5706,0.3736,0.0557)
	IFPIS	(0.7752,0.2151,0.0096)	(0.6120,0.3402,0.0477)	(0.6848,0.2953,0.1990)
	IFNIS	(0.4307,0.5203,0.0489)	(0.2380,0.7067,0.0552)	(0.2663,0.6868,0.0468)

Table 9. Separation measures and the relative closeness coefficient of alternatives

Drivers	S^*	S^-	C_i^*	Rank
D1	0.0968	0.3066	0.7600	4
D2	0.1668	0.2794	0.6262	6
D3	0.2438	0.1548	0.3884	13

D4	0.0813	0.3362	0.8053	2
D5	0.3430	0.0605	0.1499	18
D6	0.1533	0.3127	0.6710	5
D7	0.1968	0.2168	0.5242	11
D8	0.0842	0.3180	0.7907	3
D9	0.2562	0.1882	0.4235	12
D10	0.1957	0.2920	0.5987	7
D11	0.3011	0.0901	0.2303	16
D12	0.1854	0.2583	0.5822	8
D13	0.2119	0.2418	0.5330	10
D14	0.3359	0.0668	0.1659	17
D15	0.0525	0.3476	0.8688	1
D16	0.2857	0.1424	0.3326	15
D17	0.2053	0.2783	0.5755	9
D18	0.2964	0.1782	0.3755	14

4. RESULTS AND DISCUSSIONS

The result of the present research work shows that "reduce cost" (D15) is the most important driver with relative closeness coefficient 0.8688, whereas "develop team sprit between employees" (D5) is the least important driver in implementation of LM in Indian SMEs with score 0.1499. Based on the relative closeness coefficient, prioritization of drivers is as follows:D15>D4>D8>D1>D6>D2>D10>D12>D17> D13>D7>D9>D3>D18>D16>D11>D14>D5. The five top most drivers i.e. D15, D4, D8, D1 and D6 which enormously influence the industries to implement LM are discussed in detail. Due to their pertinent benefits, other drivers are also help to implement LM in SMEs. For any market segment, cost of the product is a crucial factor that determines the customer's choice (Yusuf *et al.,* 1999). The selling price of product significantly influences the revenue of any organization and the only way to increase the profit margin is by reducing the product price. LM was developed in order to reduce cost and improve process flexibility through the complete elimination of waste (Yusuf *et al.*, 2002). The LM system considers not only the manufacturing cost, but also the costs associated with sales, capital investments and administration. In the UK, department of trade and industry endorse to implement LM within SMEs (Achanga *et al.*, 2006). Zhou (2012) also identified that "reduce cost" is the most influencing driver to implement LM in SMEs and suggested that implementation of LM would help in reduction of the product cost.

"Improve quality" (D4) is the second highest ranked driver with score 0.8053. These days SMEs are facing the problem of high rate of rejection. Since, the cost of raw material and manpower is too high, rejection of product due to poor quality will tremendously impact the organization. In earlier studies suggest that those organizations which implement LM philosophy achieve significant improvement in terms of quality. Thus, a quality improvement initiative motivates Indian SMEs to implement LM to improve overall quality and to remain in competitions in global business (Ghosh 2012). The third most important driver is "improve labor productivity" (D8) with score 0.7907. SMEs are extremely affected by low manpower productivity due to which they need to hire more workers to perform the work, which ultimately diminishes the profit margin of organization. Seeliger *et al.*, (2005) found that the labor productivity improves by 20% after implementation of LM. The lean system layout of the workplace allows multi-process holding by multi-functional worker due to which productivity of labor is improved multitudinously.

"Competitiveness" (D1) is the fourth most important driver with score 0.7600. Due to globalization, SMEs face ferocious challenges from domestic as well as global firms that influenced many of them to implement LM in order to enhance the competitiveness (Zhou 2012). To develop global competitiveness among Indian SMEs, government of India introduced lean manufacturing competitiveness scheme under national manufacturing competitiveness program. In unpredictable global market, LM philosophy helps the industry to handle the situation strategically through a multi-process holding by flexible workforce.

"Shortened production lead time" (D6) is the fifth top most important driver with score 0.6710. Nowadays, SMEs face huge pressure from market to produce products with shorter lead time. Ghosh (2012) also supported that reduction in production lead time is a key driver to implement LM in manufacturing industry. Due to longer lead time, inventory in terms of raw materials, work in process and finished goods will be required in higher volumes to cover the time needed to meet the customers' demands. In lean system, pull system and smaller batch size concept significantly contribute to shortened lead time due to which on time delivery performance is greatly improved. Dhandapani *et al.*, (2004) also observed that 50% reduction in lead time after adoption of lean philosophy in the steel industry.

5. CONCLUSIONS

In this immensely competitive environment, the role of SMEs is very important towards the economies of many developed and developing countries of the world. At present, SMEs of India are facing massive challenges from global competition in all aspects of business. Scarcity of raw material and high labor cost are two major factors which highly impact the small and medium manufacturing firms. In India, LM penetration in SMEs is significantly low as compared to large scale industries. LM facilitates the industry to become more reactive towards market demand with on time delivery and provide better quality products at a lesser price than their competitors. For successful adoption of LM emphasis should be in the need of ranking the drivers that motivate its implementation in SMEs. Therefore, in the present research work 18 drivers are identified from an extensive literature review and discussion with experts. Subsequently, IF-TOPSIS method has been applied to rank the drivers of LM while taking opinions of the personals from industry, academics and government. Reduce cost (D15), improve quality (D4), improve labor productivity (D8), competitiveness (D1) and shortened production lead time (D6) are top five important drivers of LM. Adoption of LM will help the SMEs to take competitive advantage and economic benefits through continuous improvement in their value stream. In emerging countries like India, too much work needs to be done to enable LM effectively and properly. The identification and understanding of the factors that motivate implementation of LM practices are important. The present study assists the shop floor managers of SMEs to identify the common drivers to implement LM in their industries. This study collected the data from a limited number of experts at Indian scenario. So, the further scope of the work could be analyzing the potential drivers while taking data from multiple experts of different countries in different sectors.

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