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Evaluating the critical success factors for lean implementation in SMEs in Northern India using VIKOR approach

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Abstract: Lean manufacturing is a proven methodology for enhancing the performance of SMEs but its application in SMEs requires some factors, i.e., critical success factors which are mandatory for boosting the implementation purposes. So, in this present investigation, 13 critical success factors that have profound effect on lean implementation have been selected after reviewing the literature and analyzed using the VIKOR approach with reference to SMEs in Northern India. VIKOR is a multi-criteria decision-making approach and an innovative method for arriving at the best solution to complex problems. The investigation reveals that management vision, training, business model, upgradation with time and participation of everyone in the organisation play a decisive role in implementing lean on the organisation floors. It is the management that prepares long time plans with a business model in mind and involves the people in them for the purpose of enhancement because they feel that it will ultimately reward them in the time to come even in times of recession.

Keywords: small and medium enterprises; SMEs; VIKOR method; critical success factors; CSFs; lean manufacturing practices; multi-criteria decision-making techniques; multi-criteria decision making; MCDM.

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1 Introduction

In the 21st century, the cost of the product to the manufactures matters a great deal in view of the stiff competition from adjacent countries (Panizzolo et al., 2012; Ghosh, 2013). This competitive environment assumes a healthy dimension when the quality of and the delivery time for the product is becomes an important factor for enhancing business performance (Saini and Singh, 2020b). These factors steer the attention of the management towards adopting a complete solution to all these problems. The only correct answer to all these problems is lean manufacturing which has the potential to keep a firm flourishing even in times of recession. Lean manufacturing got recognition in the late nineties after its emergence on the floors of the Japanese workshops. Then, its roots spread to other nations like the USA owing to its numerous features and other added characteristics (Godinho Filho et al., 2016). But its successful implementation in a developing country like India, especially in the small and medium enterprises (SMEs), depends on the presence of several critical success factors (CSFs).

SMEs in India are providing employment to largest number of people after agriculture. Enhancement of SMEs means directly uplifting the economy of the country and is a potential platform for getting a larger pie in exports (Sahoo and Yadav, 2018). Lean manufacturing is the collection of tools for enhancing productivity and reducing manufacturing costs in today's competitive world (Prabhushankar et al., 2015). In the current scenario where a large number of organisations are looking for survival apart from attaining other priorities, lean manufacturing is the only answer towards which they can direct their endeavours (Saini and Singh, 2018; Nawanir et al., 2013; Kumar and Kumar, 2016). But the implementation of lean manufacturing practices in SMEs is full of

uncertainties and risks of failure are very high. For the SMEs, it is not easy to make the implementation of lean practices on their floors in their first attempt (Gunasekaran et al., 2000). Failure of the trial projects initiated by them for implementing lean on their shop-floors proves to be a big blockade. These failures or the initial fear on the mind of the manufacturers for implementing lean springs for several factors which are termed as the CSFs. These CSFs play a significant role in developing a line of thinking which urges them to go for continuous improvements in their organisation apart from successfully implementing lean. Section 2 presents a review of the literature on lean manufacturing practices and CSFs. Section 3 dealing with research methodology depicts the research path used for the present study. It is then followed by the VIKOR analysis of the CSFs (Section 4) and leads toward the results and discussion (Section 5). Finally, the paper ends up with conclusions (Section 6), statement of the research implications (Section 7) and further recommendations for managers on this topic (Section 8).

2 Literature review

2.1 Lean manufacturing practices

Lean manufacturing practices is a set of practices aiming at enhancing the productivity and cutting down the costs for providing them a competitive edge (Mathur et al., 2013). Operational performance was found to have improved after applying lean manufacturing practices even in a fragmented way in a Brazilian study (Godinho Filho et al., 2016). Significant improvements were seen after the application of lean manufacturing practices in India too which is a developing country. Some of these are depicted in the studies of Sahoo et al. (2008), Upadhaye et al. (2010), Eswaramoorthi et al. (2011), Panizzolo et al. (2012), Mathur et al. (2013), Panwar et al. (2015), Saleeshya et al. (2015), Saini and Singh (2018) and Singh et al. (2018). Each of these studies recorded an achievement in terms of financial and other priorities. But behind the successful implementation of these lean practices, some critical factors like planning or management vision played an important part without which the implementation and sustainability of these practices would have remained beyond the reach of the manufactures (Bai et al., 2019) or their efforts would never have borne fruit. The review of literature shows that the role of the management people is a critical factor which plays a decisive role in the implementation of lean practices in SMEs.

2.2 Critical success factors

CSFs are those factors which are directly involved in the successful implementation of lean on the premises of an enterprise (Khanna et al., 2011). These factors may be influenced by regional and cultural implications. One of the benefits realised by the manufacturers is that they can use the resources in an optimised way according to their individual capacities. But lean manufacturing practices require the mandatory implementation of certain principles without which it is impossible to attain the competitive priorities. Two major studies of CSFs by authors who have studied the implementation of lean in their respective regions have come into limelight (Achanga et al., 2006; Netland, 2016). Several CSFs were identified by them from the literature review for exploring their significance in implementing lean manufacturing practices:

- *Clear and well defined written policy for quality and business goals:* The management and its level of commitment play a vital role in the transformations (Caldera et al., 2019). This is not possible without having visionary management which requires full commitment for the enhancement purposes inside the organisation. The management is the policymakers for any organisation, so focusing and framing policies for achieving priorities is significant. But this requires the longer vision of the management which in turn does consistent efforts for gains and sustainable growth (Achanga et al., 2006; Karuppusami and Gandhinathan, 2006; Timans et al., 2012; Jing et al., 2019).
- *Timely intervention of management for upgrading the existing methods of work:* As the traditional methods are going to become obsolete with the passage of time, their upgradation is essential for attaining the intended priorities (Mahapatra and Mohanty, 2007; Belhadi et al., 2019).
- *Hiring of outside professional consultants for new technology adaptation and utilisation:* This factor plays a significant role where managerial level people lacking the knowledge of lean. In such circumstances, the organisation should seek the services of professional consultancies in lean (Netland, 2016; Yadav et al., 2019; Belhadi et al., 2019).
- *Complete awareness on the part of the management of the organisation's capabilities:* The upper management should be fully aware of the capabilities and potential of the employees who are going to implement lean. The success of lean depends on whether the management is enlightened enough to understand the potential of their organisation. SMEs should carefully choose the business model for enhancing operational effectiveness on the shop floor (Pucci et al., 2017). Generally, the functioning of SMEs reflects the mindset of the proprietors (Achanga et al., 2006; Ingelsson and Mårtensson, 2014).
- *Organisational culture is well versed with the new practices being implemented:* Organisation culture may be defined as the values, ways, behaviours and ways of interacting that contribute to the social and psychological environment of the organisation. Organisation culture affects the processes in a number of ways and culture transformation should be undertaken after proper diagnosis (Pakdil and Leonard, 2017). Organisation culture in conjunction with other factors plays a vital role in the successful implementation of lean practices (Rad, 2006). Every organisation tends to have the expertise for manufacturing the product they are dealing in. But with the passage of time, introduction of new practices might become necessary for getting the expected results within the stipulated time (Achanga et al., 2006; Zhou, 2016; Gupta et al., 2013; Bhamu and Sangwan, 2014).
- *Proper training for the adoption of new practices:* Training infuses a new freshness in the workforce for bringing about the intended transformations in the organisation. The motive behind effective training is to train the staff at the grassroots level for bringing about required change for performance enhancement. Extensive training programs are a prerequisite for implementing lean practices in SMEs. But the provision of these programs is subject to the financial constraints of the organisation

(Demeter and Matyusz, 2011). No organisation can achieve the desired results until the approach is completely adopted at the thinking level (Knol et al., 2019). The thrust at the managerial level must be on the development of the workforce for effective lean implementation (Uhrin et al., 2017). The motive here is to convert the efforts into fruitful results (Sim and Rogers, 2009; Panizzolo et al., 2012; Gupta et al., 2013; Zhou, 2016; Netland, 2016).

- *Proper system for assessing technological opportunities:* Technological opportunities are the opportunities for introducing new features for advanced manufacturing methods. If an organisation has an efficient system for assessing the new features that technology has invented for in their production era, it can easily beat its rivals in this stiff competition (Bhasin, 2013; Gupta et al., 2013).
- *Top leaders pay enough attention to eliminating backsliding ways of work and improving organisation culture:* Top leaders must have sufficient knowledge of the existing methods currently being used in their organisation. So, paying attention for improving them if required in order to create a healthy work environment enhances the organisation culture within the organisation (Netland, 2016; Singh et al., 2011). In addition, the participation of each and everybody contributes significantly for enhanced work culture in the organisation.
- *Cooperation of senior employees with the fresh recruits for adopting new technologies:* The cooperation among the employees plays a crucial role in bringing about the real transformation. If senior employees willingly cooperate with their juniors, the efforts of the organisation bear fruit in the expected time. For the adoption of new technology, coordination between the old employees and the new ones must be ensured (Losonaci et al., 2011; Kundu and Manohar, 2012).
- *Willingness to provide facilitators for introducing new practices:* Time and money act as facilitators for the adoption and utilisation of new practices. These are the resources which most of the managements shy away from spending (Bakås et al., 2011; Eswaramoorthi et al., 2011; Thanki and Thakkar, 2014). As a result, the experiment ends in failure.
- *Allocation of sufficient time/funds for the upgradation of existing practices:* For the successful introduction of new methods on the shop floor, allocation of sufficient funds and time is pre-requisite (Bulak and Turkyilmaz, 2014; Chauhan and Chauhan, 2019).
- *Explaining the benefits of new technology implementation to the workers:* Implementation of new methods requires the cooperation and blessings of the workers for enhancement purposes in the organisation. If the workers are scared of the introduction of new methods, they will not give them a fair trial. In order to prepare them to willingly and honestly implement the new measures, the benefits about these measures must be driven home to them. The workers must be convinced that the growth of the organisation and that of the workers go hand in hand (Yadav et al., 2019; Belhadi et al., 2019).

- *Seeking the help of external agencies in deciding upon new practices:* In case, people from top management are unable to decide which new practices would be the most suitable one for their organisation, they can seek the help of external agencies which possess specialised knowledge in this field. This can also be helpful when government offers initiatives to boost the implementation of lean practices (Netland, 2016; Ghosh, 2013; Panwar et al., 2015).

2.3 Problem formulation

After an extensive review of literature, it is clear that these factors can play a significant role in the successful implementation of lean in SMEs. But very few studies were found that have tried to pinpoint the CSFs (Achanga et al., 2006; Netland, 2016; Belhadi et al., 2019). All these were found to be at different topographical location with different analysing methods. The literature also revealed the dearth of research regarding the CSFs in the context of a developing economy like India (Rahman et al., 2010). This research work addresses the issue of the identification of CSFs from the literature review and analyse them with the help of a multi-criteria decision making (MCDM) method, i.e., VIKOR approach in North India SMEs.

2.4 Objectives

The objectives of this study are as follows:

1 Extracting the CSFs from the literature available.

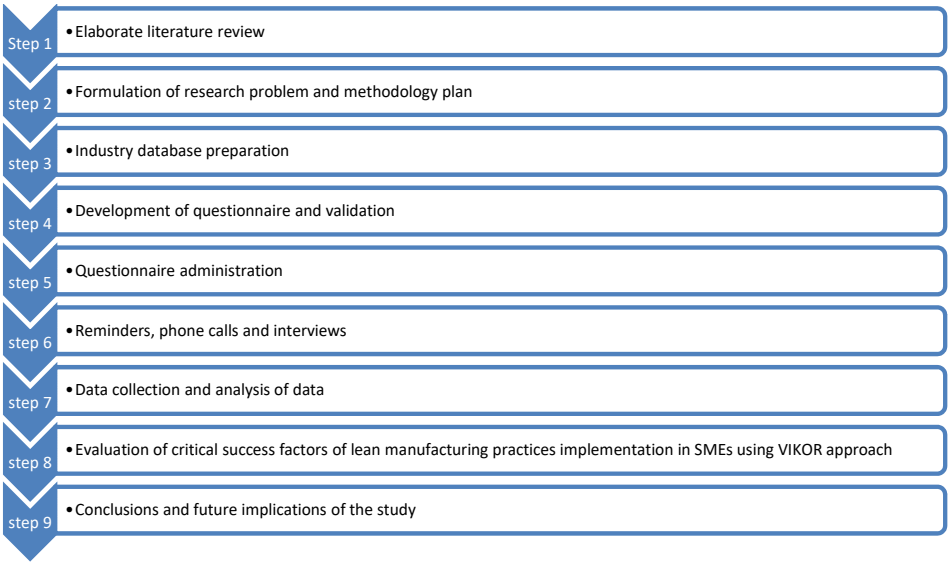
2 Prioritise them with the VIKOR approach.

3 Design of the study

This study has adopted the cross-sectional approach for the collection of data from various SMEs. Different types of approaches have been used for the collection of data from organisations (Bhamu and Sangwan, 2014). The cross-sectional approach relies on snapshots of a moment taken at a particular time while the longitudinal approach captures the moments over a span of time (Singh et al., 2013). Moreover, the cross-sectional method employs a sample of elements from the population of interest. Several authors have argued that the cross-sectional method is more beneficial than the other methods (Bhasin, 2013). The methodology employed for completing this research work is depicted in Figure 1.

For the purpose of this study, a large number of small and medium organisations especially from the MSME directory in Northern India were selected for participation in the survey (Saini and Singh, 2020a). The survey was carried out through a survey instrument keeping in mind the importance and contribution of SMEs in national economy. This survey covered the basic information about the organisation, lean practices being used, barriers to their implementation and CSFs for implementing lean practices. The questionnaire was designed after carrying out an extensive literature review and seeking the advice of academicians, lean experts in the field. The questions were framed on the Likert scale ranging from 1 to 5 aiming at the collection of some qualitatively measurable data on the basis of closed questions.

Figure 1 Methodology employed for this work (see online version for colours)



The data was collected from the SMEs through four modes: postal responses, e-mail, personal interviews and telephonic conversations. Out of the four modes, personal interview with the top plant executives, owners and managerial level people of the SMEs was found to be more fruitful than the other two. For this survey work, 900 SMEs were contacted randomly from the directories of Northern India SMEs dealing in manufacturing. The survey questionnaire was sent to them at their respective addresses with covering letter explaining the intention of the survey. After this, reminders were sent to a number of industries for sending a response or telephonic appointments were made. After deleting 15 incomplete responses, a final figure of 183 was left for consideration for the study which is quite satisfactory for analysis (Sahoo and Yadav, 2018; Dave and Sohani, 2019). It is quite evident from Figure 2 that small enterprises have contributed more than medium enterprises to this research work.

Figure 2 Depicting the contribution of enterprises in this present survey (see online version for colours)

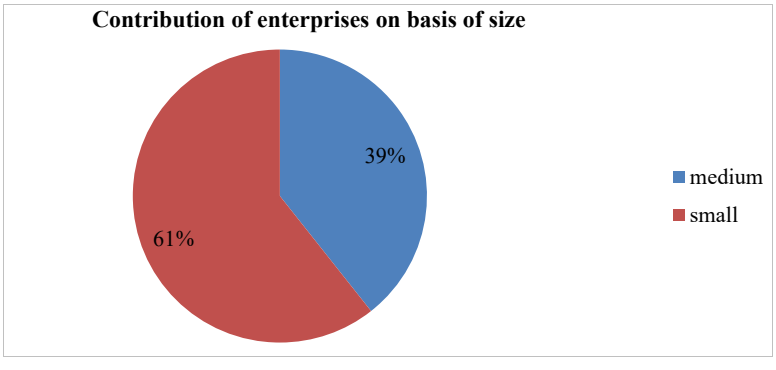


Table 1 displays the major CSF extracted from the literature review.

Table 1 Extracting CSFs from the literature review

S. no.	*Critical success factors*	*Literature review*
1	Clear and well defined policy for quality and business goals	Achanga et al. (2006), Karuppusami and Gandhinathan (2006), Timans et al. (2012), Jing et al. (2019)
2	Timely intervention for upgrading existing methods	Mahapatra and Mohanty (2007), Belhadi et al. (2019)
3	Hiring of professional consultants	Netland (2016), Yadav et al. (2019), Belhadi et al. (2019)
4	Awareness of firm capabilities for enhancing business performance	Achanga et al. (2006), Ingelsson and Mårtensson (2014), Pucci et al. (2017)
5	Organisation culture being well versed with new practices	Achanga et al. (2006), Zhou (2016), Gupta et al. (2013), Bhamu and Sangwan (2014)
6	Proper training	Sim and Rogers (2009), Panizzolo et al. (2012), Gupta et al. (2013), Zhou (2016), Netland (2016)
7	System for assessing technological opportunities	Bhasin (2013), Gupta et al. (2013)
8	Improving backsliding ways of work	Netland (2016), Singh et al. (2011)
9	Cooperation by old employees to new ones	Losonaci et al. (2011), Kundu and Manohar (2012)
10	Time and costs acts as facilitators for new practices	Bakås et al. (2011), Eswaramoorthi et al. (2011), Thanki and Thakkar (2014)
11	Sufficient allocation of time/funds for upgradation	Bulak and Turkyilmaz (2014), Chauhan and Chauhan (2019)
12	Thorough explanation of the benefits of new technology implementation to workers	Yadav et al. (2019), Belhadi et al. (2019)
13	External agencies' helps in acquiring new practices	Netland (2016), Ghosh (2013), Panwar et al. (2015)

Figure 3 CSFs according to mean score (see online version for colours)

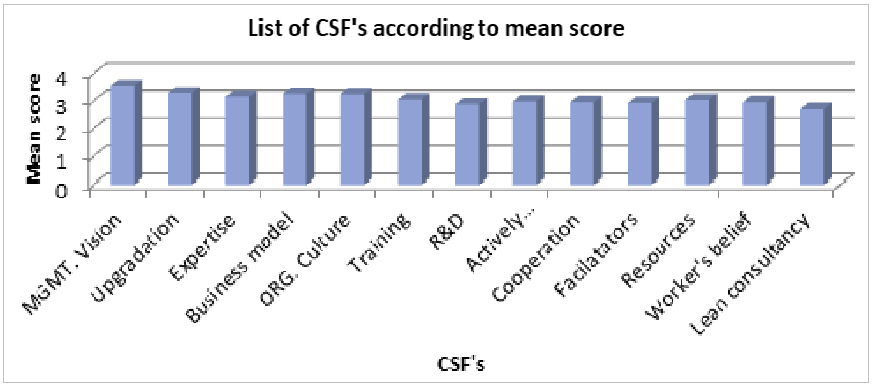
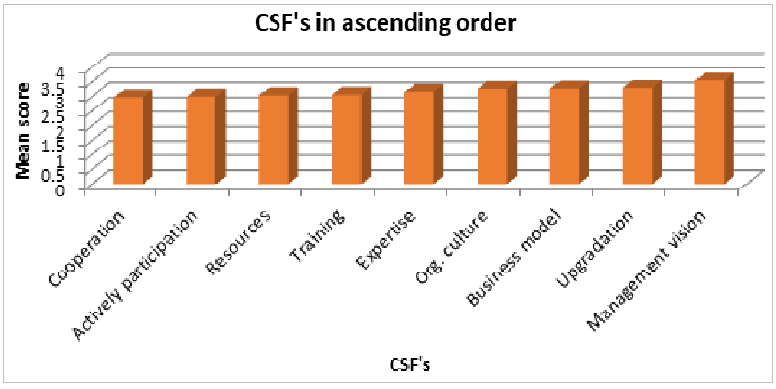


Figure 4 Arranging CSFs from least to highest (see online version for colours)



In Table 2, CSFs have been analysed through the mean score obtained from the questionnaires.

Table 2 CSFs according to their mean score

S. no.	*Critical success factors*	*Abbreviations*	*Mean score*
1	Clear and well defined policy for quality and business goals	MGMT. Vision	3.552
2	Timely intervention for upgrading existing methods	Upgradation	3.295
3	Hiring of professional consultants	Expertise	3.153
4	Awareness of firm capabilities for enhancing business performance	Business model	3.268
5	Organisation culture being well versed with new practices	ORG. Culture	3.257
6	Proper training	Training	3.060
7	System for assessing technological opportunities	R&D	2.891
8	Improving backsliding ways of work	Actively participation	3.000
9	Cooperation by old employees to new ones	Cooperation	2.973
10	Time and costs acts as facilitators for new practices	Facilitators	2.934
11	Sufficient allocation of time/funds for upgradation	Resources	3.049
12	Thorough explanation of the benefits of new technology implementation to workers	Worker's belief	2.967
13	External agencies' helps in acquiring new practices	Lean consultancy	2.721

4 Prioritising the CSFs through VIKOR approach

MCDM methods are the techniques which help us to arrive at a solution to a problem (Bai et al., 2019). One of the popular methods used these days for solving complex problems is the VIKOR method (Chatterjee and Chakraborty, 2016). The VIKOR method is a MCDM or multi-criteria decision analysis method. It was originally developed by Serafim Opricovic to solve decision making problems with conflicting and

non-commensurable (different units) criteria (Singh et al., 2020). Assuming that compromise is acceptable for conflict resolution, the decision-maker wants a solution that is closest to the ideal, and the alternatives are evaluated according to all established criteria (Ramachandran and Alagumurthi, 2013). VIKOR ranks alternatives and determines the solution that is closest to the ideal (Anvari et al., 2014). The VIKOR method was used for the selection of a lean tool in the yoghurt line for a dairy enterprise (Jing et al., 2019). Some of the reasons for selecting VIKOR approach for this present analysis are mentioned below:

1 VIKOR is a better performer than AHP or TOPSIS in case to computational complexity (Ghaleb et al., 2020).

2 VIKOR method is a better convenient to the selection of manufacturing process for agility during process of decision making, the no. of alternatives process and criteria, adequacy in supporting a group and addition or removal of criteria (Ghaleb et al., 2020).

The process of assigning weights to the criteria using VIKOR was carried out as per the following steps.

Step 1: Defining criteria

There are different CSFs which can affect the successful implementation of lean practices in manufacturing organisations. As already stated, survey approach in the form of a questionnaire has been employed in this research to extract the success factors that may help in the successful implementation of lean. Based on the survey, the responses to the questionnaire have been evaluated on the basis of mean score depicted in Table 2. After that, nine significant success factors are extracted from those responses which assist in the successful implementation of lean practices for further analysis. These factors are shown in Table 3.

Table 3 Description of attributes

S. no.	*Attributes*	*Abbreviation*
1	A clear and well-defined written policy for quality and business goals	Management vision
2	Timely intervention of the management for upgrading the existing methods of work	Upgradation
3	Awareness on the part of the management of firm's capabilities for enhancing business performance	Business model
4	Organisation culture is well versed with new practices relevant to them	Org. culture
5	Hiring of management professional consultants/people from outside for the adoption and utilisation of new technology	Expertise
6	Providing proper training for the adoption of new practices	Training
7	Allocation of sufficient time/funds for the upgradation of existing practices	Resources
8	Top leaders paying enough attention for removing the backsliding ways of work and improving organisation culture	Actively participation
9	Cooperation by senior/old employees with new ones for adopting new technologies	Cooperation

The construct of decision matrix is shown in Table 5. For this one, practitioners, academicians, HR executives, lean councillors and industrial experts who had successfully helped industrial enterprises in implementing and maintaining lean manufacturing practices with an experience of more than ten years were consulted. Their valuable response which was taken in the form of linguistic scale for the construction of decision matrix is depicted in Table 4.

Table 4 The linguistic scale used to develop pair-wise comparisons

Linguistic scale	*Numerical value*
Equally important	1
Moderately more important	3
Strongly more important	5
Very strongly more important	7
Extremely more important	9
Intermediate values	2, 4, 6, 8

Step 2: Calculation of the normalised value

Furthermore, for the process of calculation of the normalised value (Table 6), when x_{ij} is the original value of the i^{th} option and the j^{th} dimension, the formula is as follows:

$$f_{ij} = x_{ij} \Big/ \sqrt{\sum_{j=1}^{n} \left(x_{ij}\right)^2}$$

where $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots\ldots, n$.

Step 3: Determination of the best, (f) and the worst, (f–) values of all the criteria*

From the developed decision matrix for the considered problem, determination of the best, (f^*) and the worst, (f^-) values for all the criteria functions where (f^*) is the positive ideal solution for the j^{th} criteria, (f^-) is the negative ideal solution for the j^{th} criteria. The best and worst values regarding each success factor are shown in Table 7.

Step 4: Determining the weights of the attributes

To express the relative importance the weights of the attributes, their value, shown in Table 8, should be calculated as per the following formula:

$$W_j = CV_j \Big/ \sum_{j=1}^{n} CV_{ij}$$

The value of CV_j is computed as per the following formula:

$$CV_{ij} = \frac{\sigma_j}{\overline{x'_j}}$$

Table 5 Decision matrix

	Step 1:								
	MGMT. Vision	*Upgradation*	*Business model*	*ORG. culture*	*Expertise*	*Training*	*Resources*	*Participation*	*Cooperation*
MGMT. Vision	1.000	3.000	1.000	2.000	3.000	2.000	1.000	3.000	5.000
Upgradation	0.333	1.000	0.333	1.000	3.000	1.000	3.000	1.000	3.000
Business model	1.000	3.000	1.000	2.000	3.000	1.000	1.000	1.000	3.000
ORG. culture	0.500	1.000	0.500	1.000	3.000	1.000	2.000	1.000	1.000
Expertise	0.333	0.333	0.333	0.333	1.000	0.500	3.000	1.000	1.000
Training	2.000	1.000	1.000	1.000	2.000	1.000	3.000	1.000	3.000
Resources	1.000	0.333	1.000	0.500	0.333	0.333	1.000	0.333	1.000
Participation	0.333	1.000	1.000	1.000	1.000	1.000	3.000	1.000	1.000
Cooperation	0.200	0.333	0.333	1.000	1.000	0.333	1.000	1.000	1.000
Σ(Xij)^2	7.623	22.333	5.583	13.361	43.111	9.472	44.000	16.111	57.000
SQRTΣ(Xij)^2	2.761	4.726	2.363	3.655	6.566	3.078	6.633	4.014	7.550

Table 6 Normalised decision matrix

	Step 2: normalised decision matrix								
	MGMT. Vision	*Upgradation*	*Business model*	*ORG. culture*	*Expertise*	*Training*	*Resources*	*Partcipation*	*Cooperation*
MGMT. Vision	0.362	0.635	0.423	0.547	0.457	0.650	0.151	0.747	0.662
Upgradation	0.121	0.212	0.141	0.274	0.457	0.325	0.452	0.249	0.397
Business model	0.362	0.635	0.423	0.547	0.457	0.325	0.151	0.249	0.397
ORG. culture	0.181	0.212	0.212	0.274	0.457	0.325	0.302	0.249	0.132
Expertise	0.121	0.071	0.141	0.091	0.152	0.162	0.452	0.249	0.132
Training	0.724	0.212	0.423	0.274	0.305	0.325	0.452	0.249	0.397
Resources	0.362	0.071	0.423	0.137	0.051	0.108	0.151	0.083	0.132
Partcipation	0.121	0.212	0.423	0.274	0.152	0.325	0.452	0.249	0.132
Cooperation	0.072	0.071	0.141	0.274	0.152	0.108	0.151	0.249	0.132
Min (Xj-)	0.072	0.071	0.141	0.091	0.051	0.108	0.151	0.083	0.132
Max(Xj*)	0.724	0.635	0.423	0.547	0.457	0.650	0.452	0.747	0.662
Range	0.652	0.564	0.282	0.456	0.406	0.542	0.302	0.664	0.530

Table 7 Finding the best and the worst values

	MGMT. Vision	*Upgradation*	*Business model*	*ORG. culture*	*Expertise*	*Training*	*Resources*	*Partcipation*	*Cooperation*
MGMT. Vision	0.444	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000
Upgradation	0.074	0.250	0.000	0.400	1.000	0.400	1.000	0.250	0.500
Business model	0.444	1.000	1.000	1.000	1.000	0.400	0.000	0.250	0.500
ORG. culture	0.167	0.250	0.250	0.400	1.000	0.400	0.500	0.250	0.000
Expertise	0.074	0.000	0.000	0.000	0.250	0.100	1.000	0.250	0.000
Training	1.000	0.250	1.000	0.400	0.625	0.400	1.000	0.250	0.500
Resources	0.444	0.000	1.000	0.100	0.000	0.000	0.000	0.000	0.000
Participation	0.074	0.250	1.000	0.400	0.250	0.400	1.000	0.250	0.000
Cooperation	0.000	0.000	0.000	0.400	0.250	0.000	0.000	0.250	0.000
f*	1	1	1	1	1	1	1	1	1
F_	0	0	0	0	0	0	0	0	0
Range	1	1	1	1	1	1	1	1	1

Table 8 Extracting weight of the attributes

	MGMT. Vision	*Upgradation*	*Business model*	*ORG. culture*	*Expertise*	*Training*	*Resources*	*Participation*	*Cooperation*
MGMT. Vision	0.444	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000
Upgradation	0.074	0.250	0.000	0.400	1.000	0.400	1.000	0.250	0.500
Business model	0.444	1.000	1.000	1.000	1.000	0.400	0.000	0.250	0.500
ORG. culture	0.167	0.250	0.250	0.400	1.000	0.400	0.500	0.250	0.000
Expertise	0.074	0.000	0.000	0.000	0.250	0.100	1.000	0.250	0.000
Training	1.000	0.250	1.000	0.400	0.625	0.400	1.000	0.250	0.500
Resources	0.444	0.000	1.000	0.100	0.000	0.000	0.000	0.000	0.000
Partcipation	0.074	0.250	1.000	0.400	0.250	0.400	1.000	0.250	0.000
Cooperation	0.000	0.000	0.000	0.400	0.250	0.000	0.000	0.250	0.000
Average	0.302	0.333	0.583	0.456	0.597	0.344	0.500	0.306	0.278
STDEV.S	0.319	0.395	0.500	0.343	0.414	0.305	0.500	0.273	0.363
CVj	1.054	1.186	0.857	0.753	0.692	0.884	1.000	0.894	1.308
WEIGHTS	0.122	0.137	0.099	0.087	0.080	0.102	0.116	0.104	0.152

Table 9 Computing the distances of the alternatives to the ideal solution

Step 5	*MGMT. Vision*	*Upgradation*	*Business model*	*ORG. culture*	*Expertise*	*Training*	*Resources*	*Participation*	*Cooperation*	*Si*	*Ri*
MGMT. Vision	0.068	0.000	0.000	0.000	0.000	0.000	0.116	0.000	0.000	0.184	0.116
Upgradation	0.113	0.103	0.099	0.052	0.000	0.061	0.000	0.078	0.076	0.583	0.113
Business model	0.068	0.000	0.000	0.000	0.000	0.061	0.116	0.078	0.076	0.399	0.116
ORG. culture	0.102	0.103	0.074	0.052	0.000	0.061	0.058	0.078	0.152	0.680	0.152
Expertise	0.113	0.137	0.099	0.087	0.060	0.092	0.000	0.078	0.152	0.819	0.152
Training	0.000	0.103	0.000	0.052	0.030	0.061	0.000	0.078	0.076	0.401	0.103
Resources	0.068	0.137	0.000	0.079	0.080	0.102	0.116	0.104	0.152	0.838	0.152
Partcipation	0.113	0.103	0.000	0.052	0.060	0.061	0.000	0.078	0.152	0.619	0.152
Cooperation	0.122	0.137	0.099	0.052	0.060	0.102	0.116	0.078	0.152	0.919	0.152

Table 10 Finding the Q value and ranking the best one

Step 6	*Si*	*Si Max*	*Si min*	*S'*	*v = 0.5*	*Ri*	*Ri max*	*Ri min*	*R'*	*v = 0.5*	*Qi*	*RANK (Q)*
MGMT. Vision	0.184	0.919	0.184	0.000	0.000	0.116	0.152	0.103	0.264	0.132	0.132	1
Upgradation	0.583	0.919	0.184	0.543	0.271	0.113	0.152	0.103	0.207	0.104	0.375	4
Business model	0.399	0.919	0.184	0.292	0.146	0.116	0.152	0.103	0.264	0.132	0.278	3
ORG. culture	0.680	0.919	0.184	0.675	0.338	0.152	0.152	0.103	1.000	0.500	0.838	6
Expertise	0.819	0.919	0.184	0.864	0.432	0.152	0.152	0.103	1.000	0.500	0.932	7
Training	0.401	0.919	0.184	0.295	0.147	0.103	0.152	0.103	0.000	0.000	0.147	2
Resources	0.838	0.919	0.184	0.889	0.445	0.152	0.152	0.103	1.000	0.500	0.945	8
Partcipation	0.619	0.919	0.184	0.593	0.296	0.152	0.152	0.103	1.000	0.500	0.796	5
Cooperation	0.919	0.919	0.184	1.000	0.500	0.152	0.152	0.103	1.000	0.500	1.000	9

Step 5: Computing the distance of the alternatives to ideal solution

Compute the S_i (the maximum group utility) and R_i (the minimum regret of the opponent) by the following relations as shown in Table 9:

$$S_i = L_{1,I} = \sum_{j=1}^{n} w_j \left[\left(f_{ij} \right)_{\max} - f_{ij} \right] / \left[\left(f_{ij} \right)_{\max} - \left(f_{ij} \right)_{\min} \right]$$

$$R_i = L_{\infty,i} = \max_j \text{ of } \left\{ w_j \left[\left(f_{ij} \right)_{\max} - f_{ij} \right] / \left[\left(f_{ij} \right)_{\max} - \left(f_{ij} \right)_{\min} \right] \right\}$$

Step 6: Calculation of the VIKOR values Q_i and ranking of criteria

Compute the value of Q_i by using the following relation where v is the weight of the strategy for 'the majority of criteria' (or 'the maximum group utility'). When v is larger than 0.5 (> 0.5), the index of Q_i will tend to indicate majority agreement; when v is less than 0.5 (< 0.5), the index of Q_i will indicate the negative attitude of the majority; in general, v = 0.5, indicates the compromise attitude of the evaluation experts. The ranking of the success factors is shown in Table 10 (Bhosale and Kant, 2014; Dincer and Hacioglu, 2013; Rostamzadeh et al., 2015).

$$Q_i = v\left[\left(S_i - S_{\min} \right) / \left(S_{\max} - S_{\min} \right) \right] + (1 - v)\left[\left(R_i - R_{\min} \right) / \left(R_{\max} - R_{\min} \right) \right]$$

5 Results and discussion

The current study provides an organised way to identify the CSFs of lean implementation in Northern India SMEs. Firstly, 13 CSFs were extracted from the extensive literature review. Each success factor contributes significantly for lean implementation within SMEs. And after this, these were prioritised using VIKOR method after seeking expert opinion. The following observations are drawn from Table 10:

1 Management vision has occupied the first position while evolving the significant CSFs for lean implementation in SMEs. This lead towards that the approach of the management should be focused and planned for tackling with prevalent scenario, i.e., market fluctuations matters the most for beating the heat. Without having a vision for advancement to lean manufacturing, it is not feasible for SMEs to survive and thrive in open markets. This finding is consistent with other authors (Achanga et al., 2006; Netland, 2016; Sahoo, 2020).

2 Training got the second place after the management vision in success factors. This indicates the importance of training the workforce and making their mindsets fearless for inculcating the improvement practices in daily routines (Bai et al., 2019).

3 Business model is at the third position for implementing lean at their places, it is indicative of the management mindset to adopt a model base approach for making their presence felt in the market (Pucci et al., 2017). In the absence of business model approach, an organisation can diverge from the path of learning to lean one for making their operation efficient one in this open era.

4 Upgradation is at the fourth place for evaluating CSFs of lean in SMEs. This factor should get the attention for most of the manufactures working with conventional methodologies and mindset in this era of globalisation (Belhadi et al., 2019). SMEs are totally dependent upon larger enterprises for make to order products, so upgradation of methods and tools are not feasible in single point of intervention. Therefore, SMEs are advised for gradually following the upgradation process for staying alive in these turbulent times.

5 Participation of each and every one working for an organisation matters for implementing lean in the SMEs. Because SMEs work with fewer resources, less number of people and low skilled professionals. These factors stress the manufacturers of SMEs to go for optimised use of resources. This encourages the top management to get actively in ground level activities and boosting the morale of the employees for performance enhancement purposes (Netland, 2016). In addition, the hierarchy structure of the SMEs is simpler than a larger enterprise which is a positive point for improving organisation culture. Organisation culture of the organisation gets substantial improvements after removing backslides ways of work which should give prior attention for instigating lean initiatives.

6 Conclusions

Implementation of lean manufacturing practices in organisations is a challenging task especially for the SMEs in a developing country. The growth of SMEs is hurdled by a number of challenges viz. scarce resources, untrained people, lack of knowledge about lean, negative mindset of people and cultural constraints. These challenges often make the manufactures rethink about the futuristic growth of the organisation. In the present investigation, CSFs are evolved for implementing lean manufacturing within Northern India SMEs. From the investigation, it is concluded that management vision, training, business model, upgradation and participation of everyone in the organisation are the significant CSFs that impact the most for implementing lean programs. The attitude of the management, i.e., whether they want their organisation to become lean and reap the benefits or not, is always the most crucial factor. It is the management that prepares the plans to be executed in the long run with a business model on their minds and involve the people in the process of enhancement, ultimately have to pay for them. Another, critical factor viz. training is also crucial for the ground level employees to adapt themselves to the holistic approach of lean practices. Thus, this research focuses on pinpointing several CSFs for successfully implementing lean practices in the SMEs in the Northern India region using VIKOR approach.

7 Research implications

Although this study has been successful in evaluating and prioritising the CSFs for implementing lean manufacturing practices, it has some limitations too. This study was limited to the small and medium organisations located in Northern India and belonging to the manufacturing sector only. The scope can be extended further to include the type and nature of the product upon which SMEs are dependent. The findings of this study can

also be empirically validated through case studies in different sectors. Other approaches like TOPSIS, PROMTHEE and ANP can also be used for investigating these factors.

8 Managerial implications

The study has been successful in analysing and prioritising CSFs for lean in SMEs in context of developing economy. There are several recommendations for the managers of these SMEs who can enhance their performance in systematic and schematically way by LMPs. They have to establish their vision with a mindset to recognise the long-term gains and after this one; more attention will be required to focus on training programs and participation of everyone in the organisation. These priorities led towards them in a direction for adopting a business model approach with some upgradation from the existing resources.

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