Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 11, November -2017

Comparative study of Leanness Index methods for manufacturing organizations

Lalit Rajpurohit[1],Dr. A. K. Verma[2], Manpreet Singh[3],Lalit Jyani[4]

[1,2,3]*Production and Industrial Engineering Department, MBM Govt. Engineering College,Jodhpur, 342001, Rajasthan, India*

[4]*Mechanical Engineering Department, MBM Govt. Engineering College,Jodhpur, 342001, Rajasthan, India*

Abstract-*The Purpose of this paper is to identify the leanness index of the organizations using multiple models.The leanness index of three SME's are identified using the predefined models.It is identified that the results obtained through these models are in line with each other. The case study has been conducted only by taking qualitative and benefit factor. Only SME's are selected for a case study.The comparative study between the three predefined models and development of proposed model followed by a real-world case study is the original contributions under this paper.*

Keywords *- Leanness assessment, leanness level, leanness index, Fuzzy, MCDM.*

1. Introduction

In today's competitive environment, every organization is trying to get better every day so that they can compete with their global rivals. Lean thinking which evolved in Japan is presently the best thinking for everyday improvement also termed as continuous improvement (Anand and Kodali, 2009). Lean production principles and methods, which has been one of the most dominant research areas in Operation Management (Shah and Ward, 2003), have proven to be one of the most effective methods for manufacturing and service organizations (Pakdil and Leonard, 2014). Anand and Kodali (2009) also identifies that the lean manufacturing approach is a more effective manufacturing technology as compared to the CIMS and traditional manufacturing systems. Further, the lean manufacturing concept can be implemented in any type of industries whether it is a product based, process based, or the mass production based. The lean concept is equally applicable to small, medium or large organizations.

Many of the organization have tried to implement lean thinking but there are more stories about the failure of implementing it rather than success (Bhamu and Sangwan, 2014; Amin, 2013). Why is that type of ambiguity associated with the lean implementation? Many of the researchers did their research and identify that the major problem is that the implementing organization was not able to assess their leanness index before the lean implantation and after the lean implementation (Amin, 2013).Another problem is that they are not able to identify all the performance indicators that affect the leanness level of an organization (Vidhyadhar *et al.*, 2016).

II. Literature review

Based on the literature review, it is found that most of the researchers used fuzzy MCDM approach by taking qualitative factors to assess the leanness level of an organization. It is also be found that most of the researchers used the multi-grade approach for collecting the data from experts, as shown in Table 1.

Table 1 Literature review

Papers	MCDM	Qualitative	Qualitative	Fuzzy MCDM	Weight and Rating
Prasad (1995)		x			
Hines and Rich (1997)		x			
Singh *et al.*, (2006)		x		x	
Anand and Kodali (2009)	x	x			
Zanjirchi *et al.*, (2010)	x	x		x	x
Vinodh *et al.*, (2011)	x	x			
Vinodh *and* Kumar., (2012)		x		x	x
Vinodh and Vimal (2012)	x	x		x	x
Amin and Karim (2013)			x		
Kumar *et al.*, (2013)		x		x	x
Vimal and Vinodh (2013)		x		x	x
Wan and Tamma (2013)	x	x	x		
Anvari *et al.*, (2014)	x	x			x
Hojjati and Anvari (2014)	x	x			x
Pakdil and Leonard (2014)		x	x		
Vinodh *et al.* , (2014)		x		x	x
Jing *et al.*, (2015)	x				x
Alaskari *et al.*, (2016)			x		x
Vidhyadhar *et al.*, (2016)		x	x	x	x
Agarwal *et al.*, (2017)		x		x	x
Ruben *et al.*, (2017)		x		x	x

A.Findings

Through literature review, it is evident that no study has involved the multiple firms to compare the leanness level between them. Most of the leanness assessment models did not justify the feasibility of the model. There is no proper selection of lean performance indicator that justifies the entire manufacturing organization. There is no standard method to identify the fuzzy lean index of an organization.

The literature review is also being used to identify the lean performance indicators and leanness assessment methods.Through this, six enablers, thirty criteria and ninety-two sub-criteria are selected and three methods have been chosen for leanness assessment. The selected lean performance indicators are shown in Appendix A, and the methods for leanness assessment are explained below:

B.Leanness assessment models

There are many researchers who didextensive research and identified a number ofmethods to assess the leanness index of an organization that involves qualitative assessment, quantitative assessment, fuzzy assessment, multi-criteria decision-making assessment and so on (Narayanmurthy and Gurumurthy, 2016).

Now it is also an ambiguity that which assessment model should organization has to choose to assess the leanness of their organization?

As lean assessment of organizations is associated with real-life problems and According to Zimmermann (2011):

1.In dealing with the real-world situation, the real world situations are very often not crisp and deterministic, and they can not be described precisely.

2. The complete description of a real system often would require far more detailed data than a human being could ever recognize simultaneously, process, and understand.

So to handle this, multi grading linguistic approach is used for collecting a data and fuzzy logic is used for decision-making, as assessment of leanness using multi-grade fuzzy logic approach is practically feasible (Vinodh and Vimal, 2012; Vinodh *et al.*,2011).The selection of linguistic terms and their triangular fuzzy numbers for importance weight, performance rating, and leanness level is based on the previous literature done by Vidhyadhar *et al.*, 2016; Vinodh and Vimal, 2012; Vimal and Vinodh, 2013; Zanjirchi *et al.*, 2010). The linguistic variable (membership function) and its respective triangular fuzzy number for Importance Weight (IW) and Performance Rating (PR) are defined under the space [0, 1] and [0, 10] as shown in Table 2.

Table 2 Linguistic variables and triangular fuzzy numbers for importance weight and performance rating

Importance Weight		**Performance Rating**	
Linguistic variable	Triangular fuzzy number	Linguistic variable	Triangular fuzzy number
Very Low (VL)	(0, 0.05, .1)	Worst (W)	(0, 0.5, 1.5)
Low (L)	(.1, .2, .3)	Very Poor (VP)	(1, 2, 3)
Fairly Low (FL)	(.2, .35, .5)	Poor (P)	(2, 3.5, 5)
Medium (M)	(.3, .5, .7)	Fair (F)	(3, 5, 7)
Fairly High (FH)	(.5, .65, .8)	Good (G)	(5, 6.5, 8)
High (H)	(.7, .8, .9)	Very Good (VG)	(7, 8, 9)
Very High (VH)	(.8, .95, 1)	Excellent (E)	(8, 9.5, 10)

C. Gathering the data from the experts of firms

The questionnaire is given to at least two experts of each firm to avoid biasness. They have to answer each question in the linguistic term. The sample of collected data from the experts of firmA, firm B and firm C are shown in table 3

Table 3 LPI's answers of Firms by experts

Code	Lean Performance Indicator	Firm A				Firm B						Firm C			
		Expert 1		Expert 2		Expert 1		Expert 2		Expert 3		Expert 1		Expert 2	
		IW	PR	IW	PR	IW	PR	IW	PR	IW	PR	IW	PR	IW	PR
1	Involvement of Shop floor management (SFM) team in working on the shop floor	FH		FH		H		H		H		H		H	
11	*Involvement of SFM team in production scheduling*	FH		FH		H		H		H		VH		VH	
111	Use of Continuous flow of production	M	F	M	F	VH	F	H	F	FH	F	VH	E	VH	VG
112	Use of Standardized work	M	F	M	F	H	F	H	F	VH	F	VH	E	VH	VG
113	Use of U-shaped layout	M	W	M	W	M	F	FH	P	FH	P	H	VG	H	VG
12	*Involvement of SFM team in setup time reduction*	FL		FL		M		FH		M		H		H	
121	Use of jigs and fixture	H	G	H	G	L	G	FH	F	VH	F	VH	E	VH	E

122	Use of Checklist for setup	FL	VP	FL	VP	H	G	H	P	VH	P	VH	E	VH	E
123	SMED implementation in changeover production	FL	VP	FL	VP	FL	P	FH	F	FH	F	L	G	FL	VG

The details of the organizations are given in table 4.

Table 4 Details of organizations

	Firm A	**Firm B**	**Firm C**
Location	Jodhpur (Raj.) (India)	Jodhpur (Raj.) (India)	Jodhpur (Raj.) (India)
Type	SMEs	SMEs	SMEs
Product	Submersible pumps	Healthcare products	Healthcare products
Number of employees	65	100	150
Total turnover	10 Cr.	6 Cr.	30 Cr.
Designation of Experts	AGM	CEO	Production manager
	Design and production manager	Works manager	Q&A manager
		General manager	

D. Aggregating the expert's opinion of respected firms

The method for aggregating the fuzzy numbers with q number of experts is calculated using equation (1):
Consider a fuzzy triangular number and its membership function

$$\boldsymbol{x_{ijkq} = (l_{ijkq}, m_{ijkq}, u_{ijkq})}$$

Where:

i, j, k= Numbers of enablers, criteria, and sub-criteria respectively.

q = number of experts, q = 1, 2,…, Q.

The aggregate fuzzy triangular number

$$\boldsymbol{\tilde{x}_{ijk} = (\tilde{l}_{ijk}, \tilde{m}_{ijk}, \tilde{u}_{ijk})} \qquad (1)$$

Where:

$$\tilde{l}_{ijk} = min(l_{ijkq})$$
$$\tilde{m}_{ijk} = \frac{1}{Q}\sum(m_{ijkq})$$
$$\tilde{u}_{ijk} = max(u_{ijkq})$$

E. Normalization of fuzzy number

The normalization of Fuzzy numbers belonging to the benefit and cost categories is carried out using the equations (2) and (3) developed by Chen (2000) (Kumar *et al.*, 2013).

For benefit criteria

$$\boldsymbol{r_{ijk} = \left(\frac{l_{ijk}}{u_k^+}, \frac{m_{ijk}}{u_k^+}, \frac{u_{ijk}}{u_k^+}\right), k \in B} \qquad (2)$$

And for cost criteria

$$\boldsymbol{r_{ijk} = \left(\frac{l_k^-}{u_{ijk}}, \frac{l_k^-}{m_{ijk}}, \frac{l_k^-}{l_{ijk}}\right), k \in C} \qquad (3)$$

Weighted normalized fuzzy performance rating

Weighted normalized fuzzy ratings for all the lean performance indicators are calculated by multiplying the normalized performance rating with relative weights using equation (4) (Vidhyadhar *et al.*, 2016; Kumar *et al.*, 2013).

$$V_{ijk} = W_i * W_{ij} * W_{ijk} * r_{ijk} \quad (4)$$

Method 1

It is a distance minimization technique. So the computed crisp number is the weighted average point or the nearest point of the respected fuzzy number. (Agarwal *et al.*, 2017; Asady and Zendehnam, 2007). The nearest point the fuzzy number of ($M2_{ijk}$) is calculated using equation (5).

$$\mathbf{M1}_{ijk} = \frac{(l_{ijk} + 4 * m_{ijk} + u_{ijk})}{6} \quad (5)$$

The value of nearest point M of leanness parameters is directly proportional to the degree of its contribution to the leanness level (Agarwal *et al*., 2017; Vinodh and Vimal, 2012.

Method 2

This method is also a distance minimization technique, developed and tested by Asady and Zendehnam (2007). In this, the $V_{ijk}$is converted into a crisp number using equation (6)

$$M2_{ijk} = l_{ijk} + \frac{u_{ijk} - m_{ijk}}{4} \quad (6)$$

The value of M of leanness parameters is directly proportional to the degree of its contribution to the leanness level (Agarwal *et al*.,2017; Vinodh and Vimal, 2012).

Method 3

In this, The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is used, improved by Chen (2000), and used by Kumar *et al.*, (2013) for leanness assessment. Method 3 consist three steps.

Step 1: After calculating the V_{ijk} ,the Fuzzy positive ideal solution (FPIS) (I^+) and Fuzzy negative ideal solution (FNIS) (I^-) are computed using equations (7) and (8).

$$I_{ijk}^{+} = \max\{V_{ijk}\} \quad (7)$$

$$I_{ijk}^{-} = \min\{V_{ijk}\} \quad (8)$$

Step 2: The distance of each lean performance parameter from I_{ijk}^{+} and I_{ijk}^{-} is computed using the Equations (9) and (10).

$$d^{+}(v_{ijk}, I_{ijk}^{+}) = \left\{\frac{1}{3}\sum(v_{ijk}(x) - I_{ijk}^{+}(x))^2\right\}^{1/2} \quad (9)$$

$$d^{-}(v_{ijk}, I_{ijk}^{-}) = \left\{\frac{1}{3}\sum(v_{ijk}(x) - I_{ijk}^{-}(x))^2\right\}^{1/2} \quad (10)$$

Step 3: Compute the closeness coefficient.

The closeness coefficient (CC) represents the distance of each lean performance parameter from FPIS and FNIS and is calculated using equation (11).

$$CC = \frac{d_{ijk}^{-}}{(d_{ijk}^{-} + d_{ijk}^{+})} \quad (11)$$

The average closeness coefficient shows the relative leanness level of an organization (Kumar *et al*., 2013).

Results

The average nearest point or LI is calculated using method 1, method 2, and method 3 for each firm are shown in Table 4. As per the results obtain from method 1, method 2, and method 3, it can be seen that the LI of firm C is better than the LI of firm B and LI of firm B is better than LI of firm A.

Table 5. Average Value of nearest point

	Firm A	Firm B	Firm C
$\bar{M}1_{ijk}$	0.1124336	0.2628567	0.4760551
$\bar{M}2_{ijk}$	0.0662194	0.1409103	0.3016991
$\overline{CC}$	0.4538042	0.4630009	0.4893271

III. Conclusion

An extensive literature has been done for selecting the best suited method for comparing the LI of the organizations. The results obtain from method 1, method 2, and method 3 shows the in line results that the LI of firm C is better than the LI of firm B and LI of firm B is better than LI of firm A. By studying those models it has been found that the complexity of calculating the LL is getting increases with increasing the number of parameters so new method can be developed to assess the LI of organization. In this study, only the benefit criteria are taken into care so in future, the combination of both cost and benefit criteria can be used. The selected organizations are manufacturing organization. In future, the service organization or hybrid organizations can be considered. The survey is conducted in small-scale organization. In future, large industries can be considered.

References

[1]. Agrawal, R., Agrawal, R., Asokan, P., Asokan, P., Vinodh, S. And Vinodh, S., 2017. Benchmarking fuzzy logic and ANFIS approaches for leanness evaluation in an Indian SME: A case study. Benchmarking: An International Journal, 24(4), pp.973-993.

[2]Amin, M.A., 2013. A systematic approach for selecting lean strategies and assessing leanness in manufacturing organizations.

[3]Anand, G. And Kodali, R., 2009. Selection of lean manufacturing systems using the analytic network process–a case study. Journal of Manufacturing Technology Management, 20(2), pp.258-289.

[4]Asady, B. and Zendehnam, A., 2007. Ranking fuzzy numbers by distance minimization. Applied Mathematical Modelling, 31(11), pp.2589-2598.

[5]Bhamu, J. and Singh Sangwan, K., 2014. Lean manufacturing: literature review and research issues. International Journal of Operations & Production Management, 34(7), pp.876-940

[6]Chen, C.T., 2000. Extensions of the TOPSIS for group decision-making under fuzzy environment. Fuzzy sets and systems, 114(1), pp.1-9

[7]Narayanamurthy, G., Narayanamurthy, G., Gurumurthy, A. and Gurumurthy, A., 2016. Leanness assessment: a literature review. International Journal of Operations & Production Management, 36(10), pp.1115-1160.

[8]Pakdil, F. And Leonard, K.M., 2014. Criteria for a lean organization: development of a lean assessment tool. International Journal of Production Research, 52(15), pp.4587-4607

[9]Shah, R. and Ward, P.T., 2003. Lean manufacturing: context, practice bundles, and performance. Journal of operations management, 21(2), pp.129-149

[10]Vidyadhar, R., Sudeep Kumar, R., Vinodh, S. And Antony, J., 2016. Application of fuzzy logic for leanness assessment in SMEs: a case study. Journal of Engineering, Design, and Technology, 14(1), pp.78-103

[11]Vimal, K.E.K., and Vinodh, S., 2013. Application of artificial neural network for fuzzy logic based leanness assessment. Journal of Manufacturing Technology Management, 24(2), pp.274-292.

[12]Vinodh, S. And Vimal, K.E.K., 2012. Thirty criteria based leanness assessment using fuzzy logic approach. The International Journal of Advanced Manufacturing Technology, 60(9-12), pp.1185-1195.

[13]Vinodh, S., Shivraman, K.R. and Viswesh, S., 2011. AHP-based lean concept selection in a manufacturing organization. Journal of Manufacturing Technology Management, 23(1), pp.124-136

[14]Vinodh, S., Thiagarajan, A. And Mulanjur, G., 2014. Lean concept selection using modified fuzzy TOPSIS: A case study. International Journal of Services and Operations Management, 18(3), pp.342-357.

[15]Zanjirchi, S.M., Tooranlo, H.S. and Nejad, L.Z., 2010, January. Measuring organizational leanness using fuzzy approach. In Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management (pp. 144-156).

[16]Zimmermann, H.J., 2011. Fuzzy set theory—and its applications. Springer Science & Business Media.