A Theoretical Analysis for Prioritization of Lean Strategies: A Survey of Indian Manufacturing Industries

Virender Chahal and M. S. Narwal

Abstract The purpose of this paper is to discover the lean strategies prioritization in Indian manufacturing industries. It also aims to select the best strategy for industries. It also helps to improve the performance of implemented lean strategies. This research provides a ranking of implemented lean strategies with grey relational analysis (GRA). Evaluating data were collected from seven different industrial experts in terms of four lean performance criteria such as cost, time, quality and flexibility. Here, fuzzy five Likert scale weighted methods are used which are integrated into the GRA with respect to weight the lean performance criteria. This study provides the priority of lean strategies based on selected criteria using the GRA method which is very effective, and the result will help decision-makers to recognize the best strategy in Indian manufacturing industries. To make results more effective, data were collected from 11 different manufacturing industries which will help in future and criteria can be more for a better result. Moreover, as an interesting proposal, the fuzzy linguistic environment may be further incorporated into the practical as per GRA results. In distinction to preceding research, it sets apart for priority based on the scores of GRA with performance criteria. Furthermore, there is very less work available in the literature with GRA for prioritization.

Keywords Grey systems · Indian manufacturing industries · Prioritization · Lean strategies · Grey relational analysis

1 Introduction and Literature Review

In today scenario, lean manufacturing (LM) is not a new word in the manufacturing sector. Every grooving industry is focusing to implement of LM because of innovative

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strategies for better quality and best customer satisfaction [1]. It has been approved by entire worldwide for implementation in many industrial sectors, i.e. automobiles, fabrication, manufacturing and public sectors, for minimization of wastes. So it can be said that LM is not only used for manufacturing industries, but also used all over. LM is a mixture of different lean strategies which are 5'S, JIT TQM, TPM, lean training, kaizen, lean thinking, Kan-Ban, zero defect concept, VSM, Six Sigma, etc. [2]. LM delivers superior accuracy and improved productivity with high customer satisfaction with strategies like VSM [3].

After World War II, in Toyota motor company, Eiji Toyoda and Taiichi Ohno find out a way for better quality that was "Toyota Production System" and today is known as "lean system (LS)". LS provide sets of maintenance for higher quality with fewer breakdowns [4]. According to [5], kaizen implementation with lean provides high quality in the industry. Here, industrial wastes can consider the activity such as value-added activity, nonvalue-added activity and necessary nonvalue-added activity. Wastes are unwanted in the industry as well as outside industry that can be eliminated, but it is also so difficult to eliminate. Kaizen is an effective strategy with continuous change for higher quality and better productivity. JIT is a pull system which prevents extra financially like excessive inventory and pressure on the industry. According to [6], lean is the successive agent to improve business scenario in current manufacturing era.

1.1 Research Need and Motivation

Here, question arises that which lean strategy is more effective in Indian manufacturing field. The Indian manufacturing sector is the fastest rising sector around the world. The manufacturing sector is the major pillar of the entire economic development of the country [7]. The manufacturing industries have been implemented LM and their strategies, but they do not know that which strategy is more effective. From last few years, Indian manufacturing industries are focusing on a best way to improve quality with minimum cost and best customer satisfaction, and this research will help them to identify [8]. If industries will know their prioritization with lean strategies, the industry quality will be high with good customer satisfaction. So it is very important to know lean strategies effectiveness as per their prioritization after the successful implementation of LM [9]. A successful implementation only can be possible if we have identified the system strong and weak points to improve [10].

1.2 Research Questions

To understand lean manufacturing concept
To study lean strategies
To explore the status of lean strategies by industrial experts
Prioritization of studied lean strategies

1.3 Research objective

Selection of LS
Selection of LS performance criteria
Select the prioritization method
Prioritization of LS based on selected LS performance criteria

There are so many techniques for prioritization for lean strategies, but grey relation analysis (GRA) is one of the most suitable methods for it [11]. After studying the literature, it is found that the GRA approach is a latent key for prioritization. GRA approach is used for multi-objective optimization which is practical on the calculated response results to select most preferred lean strategy in Indian manufacturing industry [12]. Response results are collected from different lean industrial experts from different industries with help of a well-designed questionnaire.

2 Methodology

This papers result to prioritization of lean strategies which are 5'S, JIT, TPM, TQM and lean training. These selected lean strategies are selected by literature review. These are more dominating as compared to other lean strategies. This prioritization is based on GRA theory, and required data have been collected from seven industrial experts which have good implementation knowledge about LM. These lean strategies will be rated with help of fuzzy Likert scale five with identified their LM selection criteria's: cost, time, quality and flexibility. All required data will be collected with a well-oriented questionnaire. The linguistic response will be converted into fuzzy numbers and then rated with GRA.

2.1 Data Analysis

After prepare questionnaire, it is sent to different industrial experts to find the priority for the industry as per selected lean strategy selection criteria. Different seven expert's

data have been collected and got the average effect by the well-statistical tool to find the overall result. The responses have been arranged and shown in Table 1.

Selection scale for cost and time is as follows: extremely high—5, very high—4, high—3, low—2, very low—1 (lower the better).

Selection scale for quality and flexibility is as follows: extremely high—1, very high—2, high—3, low—4, very low—5 (higher the better).

Table 1 Combined response of industrial experts

Experts	Lean strategies → / Lean criteria ↓	5'S	JIT	TPM	TQM	Lean training
1	Cost	High	High	Very high	Low	High
	Time	High	Low	High	Low	High
	Quality	Very low	Very low	Very low	Low	Very low
	Flexibility	Very low	Low	High	High	Very low
2	Cost	High	High	Very high	Very low	Low
	Time	Very high	Low	High	Low	Low
	Quality	Low	Very low	Low	Low	Low
	Flexibility	Very low	Low	High	High	Very low
3	Cost	High	Very high	High	Low	High
	Time	High	Low	High	Low	High
	Quality	Very low	Very low	Very low	Low	Very low
	Flexibility	Very low	Low	High	High	Very low
4	Cost	High	High	High	Low	High
	Time	Very high	Low	High	Low	High
	Quality	Very low	Low	Very low	Low	Low
	Flexibility	Very low	Low	High	High	Very low
5	Cost	High	High	High	Low	High
	Time	High	Low	High	Low	High
	Quality	Very low	Very low	Low	Low	Very low
	Flexibility	Very low	Low	High	High	Very low
6	Cost	High	Very high	Very high	Low	High
	Time	High	Low	High	Low	High
	Quality	Very low	Low	Low	Low	Very low
	Flexibility	Low	Low	High	High	Very low
7	Cost	High	High	Very high	Low	High
	Time	High	Low	High	Low	High
	Quality	Very low	Very low	Very low	Low	Very low
	Flexibility	Low	Very low	Very high	High	Low

After arranging, the linguistic response result has been converted into the mathematical form shown in Table 2.

Every expert has a different opinion about the selection and prioritization of lean strategies. So it needs to make a common decision of all experts to prioritization lean strategies which is shown in Table 3. It can be solved with an average of all industrial expert response to make average response result.

Table 2 Mathematical value response

Experts	Lean criteria	5'S	JIT	TPM	TQM	Lean training
1	Cost	3	3	4	1	3
	Time	3	1	3	1	3
	Quality	2	2	2	1	2
	Flexibility	2	1	3	3	2
2	Cost	3	3	4	2	1
	Time	4	1	3	1	1
	Quality	1	2	1	1	1
	Flexibility	2	1	3	3	2
3	Cost	3	4	3	1	3
	Time	3	1	3	1	3
	Quality	2	2	2	1	2
	Flexibility	2	1	3	3	2
4	Cost	3	3	3	1	3
	Time	4	1	3	1	3
	Quality	2	1	2	1	1
	Flexibility	2	1	3	3	2
5	Cost	3	3	3	1	3
	Time	3	1	3	1	3
	Quality	2	2	1	1	2
	Flexibility	2	1	3	3	2
6	Cost	3	4	4	1	3
	Time	3	1	3	1	3
	Quality	2	1	1	1	2
	Flexibility	1	1	3	3	2
7	Cost	3	3	4	1	3
	Time	3	1	3	1	3
	Quality	2	2	2	1	2
	Flexibility	1	2	4	3	1

Table 3 Average response result for all experts

Lean strategies	Cost	Time	Quality	Flexibility
5'S	3	3.29	1.86	1.71
JIT	3.29	1	1.71	1.14
TPM	3.57	3	1.57	3.14
TQM	1.14	1	1	3
Lean training	2.71	2.71	1.71	1.86

After making an average response, next step into implement GRA for best result individual for all lean strategies select criteria's which are cost, time, quality and flexibility (Tables 4, 5, 6 and 7).

Table 4 GRA analysis for cost

Lean strategies	Average of all experts responses	Normalized value	Deviation	GRC
5'S	3	0.235	0.765	0.395
JIT	3.29	0.115	0.885	0.361
TPM	3.57	0.000	1.000	0.333
TQM	1.14	1.000	0.000	1.000
Lean training	2.71	0.354	0.646	0.436

Table 5 GRA analysis for time

Lean strategies	Average of all experts responses	Normalized value	Deviation	GRC
5'S	3.29	0.000	1.000	0.333
JIT	1	1.000	0.000	1.000
TPM	3	0.127	0.873	0.364
TQM	1	1.000	0.000	1.000
Lean training	2.71	0.253	0.747	0.401

Table 6 GRA analysis for quality

Lean strategies	Average of all experts responses	Normalized value	Deviation	GRC
5'S	1.86	0	1.000	0.333
JIT	1.71	0.174	0.826	0.377
TPM	1.57	0.337	0.663	0.430
TQM	1	1	0.000	1.000
Lean training	1.71	0.174	0.826	0.377

Table 7 GRA analysis for flexibility

Lean strategies	Average of all experts responses	Normalized value	Deviation	GRC
5'S	1.71	0.715	0.285	0.637
JIT	1.14	1	0.000	1.000
TPM	3.14	0	1.000	0.333
TQM	3	0.07	0.930	0.350
Lean training	1.86	0.64	0.360	0.581

Table 8 Weight for lean strategy selection criteria by experts

Selection criteria for lean strategies	Experts weight notation	Industrial experts weight for selection criteria
Cost	Wc	0.50
Time	Wt	0.25
Quality	Wq	0.15
Flexibility	Wf	0.10

Similarly, weight shown in Table 8 is the average given by the different industrial experts, and it can vary as per the industry implementation, where industrial weight can be varied according to industries which implement LS.

2.2 Method to Apply GRA

Normalize the collected data shown in Tables 4, 5, 6 and 7.

After normalizing, all data will be between 0 and 1.

$$x_1^*(t) = \frac{\max_i(t) - x_{1i}(t)}{\max_i(t) - \min_i(t)} \tag{1}$$

Identify deviation value with normalized data shown in Tables 4, 5, 6 and 7.

$$Dx_1(t) = 1 - x_1^*(t) \tag{2}$$

Computation of grey relational coefficients (GRCs) is noted with $\xi\ (t)$, and normally value is taken as 0.5.

Computation of grey relational grade (GRG) is shown in Table 9.

Table 9 Calculation of grey relational grade (GRG)

Lean strategies	GRC ξ (t) (cost)	GRC ξ (t) (time)	GRC ξ (t) (quality)	GRC ξ (t) (flexibility)	GRG	%	Rank order
5'S	0.395	0.333	0.333	0.637	0.395	14.60	4th
JIT	0.361	1.000	0.377	1.000	0.587	21.69	2nd
TPM	0.333	0.364	0.430	0.333	0.356	13.16	5th
TQM	1.000	1.000	1.000	0.350	0.935	34.55	1st
Lean training	0.436	0.401	0.377	0.581	0.433	16.00	3rd
Total GRG					2.706		

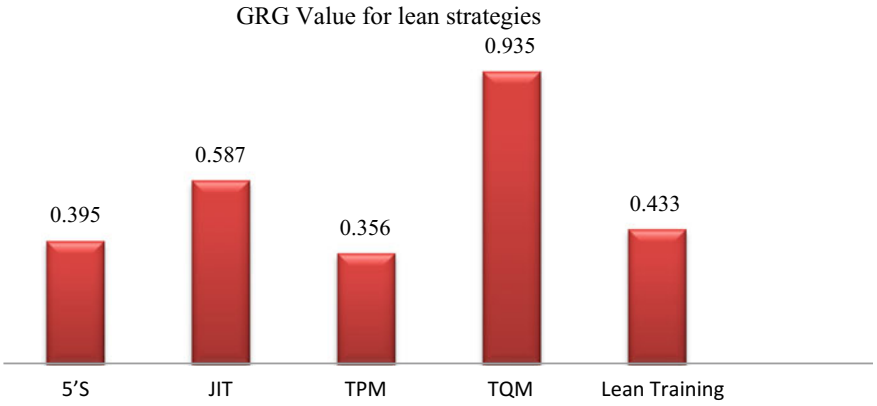

Fig. 1 Chart 1—GRG value for lean strategies

GRC will be the multiple of all GRC values with their related weight given by experts and then the summation of all, i.e.

$$\begin{aligned}\text{GRG for } 5'\text{S} =& \text{GRC(cost)} * \text{Wc} + \text{GRC(time)} * \text{Wt} + \text{GRC(quality)} * \text{Wq} \\ &+ \text{GRC(flexibility)} * \text{Wf} = 0.395 \end{aligned} \tag{3}$$

Similarly, GRG results for other lean strategies are shown in Table 9 (Fig. 1).

3 Results and Conclusion

After the complete study, it is found that GRA theory is very precise and effective to reflect the well-maintained prioritization of implemented lean strategies. As per the industrial present competitive behaviour, lean strategies must be prioritization

and GRA theory has very effective results. As result shown in Chart 1, it is clear that TQM is more dominating for manufacturing industry. JIT is in second position, and lean training is at number third. The whole study is based on survey analysis of different industries that know and implemented lean manufacturing. 5'S, JIT, TPM, TQM and lean training are the most useful and implemented strategies for manufacturing industries, so these are considered. After GRC identification, a sole result comes out about lean strategies, but the next thing which will affect is related weight. This weight will be given by industry. For further study, individual industry can be analysed to find its relative priority. Also, we can consider different lean strategies and different other industries for better results.

Future researcher can consider remaining lean strategies and can consider more industries to make research more precise and accurate in present Indian scenario.

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