Lean Six Sigma: a clinical treatment for the recovery of Indian manufacturing sector from the after-effects of coronavirus

Harsimran Singh Sodhi
Department of Mechanical Engineering, Chandigarh University, Mohali, India

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Abstract

Purpose – Manufacturing industry is quite badly hit due to the coronavirus. Manufacturing has been stopped in every country. The present study will provide assistance to the practitioners to recover manufacturing sector from the after-effects of coronavirus.

Design/methodology/approach – A thorough review of the recent articles published in the newspaper and web has been done to make a viewpoint on the global industrial impact due to epidemic corona. Reports of WHO, IMF, World Bank, RBI and so forth are also reviewed. Further, Lean Six Sigma has been suggested which can be implemented to recover manufacturing industry from the ill effects of corona.

Findings – In present study the problem causd in the manufacturing sector due to corona virus has been identified and a clinical treatment for the same has been proposed by using the tools and techniques of Lean Six Sigma.

Originality/value – The impact of coronavirus has become a huge issue not only for the physical health of human beings but also for the economic health of most of the countries in the world, as it is pushing the world economy toward huge economic depression. Therefore, it becomes the moral responsibility of industrial experts to suggest the tools and techniques to the manufacturing industry for faster recovery.

Keywords Lean Manufacturing, Six Sigma, Lean Six Sigma

Paper type Research paper

1. Introduction

Pandemic coronavirus has damaged the global economies to a great extent. Indian economic sentiments are also not spared from this big damage due to corona. Manufacturing industries had started shutting their production plants in the mid-March of year 2020. Due to this, they are facing huge economic losses. Some of the manufacturing sectors, especially food processing industry, are incurring heavy loss due to the inventory they stored and which is getting damaged due to its short life span. India's development as well as growth strategy has emphasized on the creation of a well-diversified industrial base to realize its prolonged dream of industry-led development. In order to maximize growth from limited resources, productivity needs is an important factor (Abdul *et al.*, 2016). Besides productivity, which is more important is the efficiency and competitiveness. It may not be out of place to state that that although the concepts of productivity, efficiency and competitiveness are indicators of performance, these need not necessarily move in tandem with each other (Albliwi *et al.*, 2014). However, improving these indicators should be conceived merely as a means to an end, and certainly not an end in itself (Allen *et al.*, 2005).

Manufacturing industry is of great importance to the development of any economy. Developing countries like India largely depend on manufacturing industry for growth and employment. India is believed to have a demographic dividend wherein the majority of population falls in the working age-group which in itself a double-edged sword. Hence, the government and policy-makers have started revisiting the Indian growth story and addressing its flaws (Andersson *et al.*, 2014). The role and importance of manufacturing

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sector comes in here both in terms of creating a self-reliant economy and in the process of generating the much-needed employment.

Indian economy, which has traditionally been agriculture-based, is taking big leaps toward promoting manufacturing which constitutes 16* of GDP in India. But, its contribution to employment sector and growth is well below its true potential. Restrictive and rigid labor laws, abundance of unskilled workforce compared to skilled workforce and lack of technology innovations are some of the factors contributing to this. Diversity of resources and the varying degree of skills and qualifications of available labor make it essential to understand the importance of both small- and large-scale industries. As we also know, the strength and potential of small-scale industries is largely dependent on the strength of our traditional skills and knowledge, which creates large employment opportunities, next only to agriculture (Antony *et al.*, 2014). It also helps in alleviation of poverty and brings about equitable distribution of income and wealth. At the same time, large-scale industry, apart from providing job opportunities, plays an important role in promoting exports, resulting in increased foreign exchange earnings and expanded demand base for domestic products, leading to overall inclusive growth. National manufacturing policy aims at enhancing the share of manufacturing in GDP to 25% by creating 100 million jobs. It also seeks to empower rural youth by imparting necessary skill set to make them employable. The recent budget of the government includes provision for providing favorable employments and facilitating promotion of domestic as well as international industry by simplification, rationalization and digitization of processes. Initiatives like "Make in India," Skill India and MUDRA are aimed at encouraging the spirit of entrepreneurship and making India the manufacturing hub of the world (Assarlind *et al.*, 2012).

Despite the emphasis on the manufacturing sector in India's planning process, the contribution of this sector, at best, is modest. It needs to increase so as to absorb more workers and to enable people to improve their standard of living. Second, the employment and output generation within the manufacturing sector exhibits a major imbalance (Augusto *et al.*, 2009). According to the latest available data, the unorganized sector accounts for about 80% of employment and only 33% of income of the manufacturing sector (Banawi *et al.*, 2014 and Bendell, 2006). Out of the total employment being generated in manufacturing sector, 86% employments are being generated in unregistered or unorganized sector, and only 14% employments are being generated in organized or registered sector of our economy (Bhuiyan and Baghel, 2005).

In the present study, various tools and techniques of Lean Six Sigma have been suggested which may give some relief to the manufacturing sector for recovering from the after-effects of coronavirus (Chandimaet and Shahanaghi, 2018).

2. Literature review

This study primarily focuses on the performance of the manufacturing sector by taking a disaggregated view of it (Sodhi, 2020). It examines all the possible factors that largely determine the productivity of the manufacturing sector, and hence the growth of our economy. In this study, special attention has been given to organized and unorganized segments of manufacturing sector and employment generation in these two segments. It is believed that though the contribution of Indian manufacturing sector to its GDP has somehow been satisfactory, especially after economic reforms, but this sector has not been able to keep the pace of employment generation. Employment generation in Indian manufacturing sector has not been as required compared to its GDP contribution (Snee, 2010).

Manufacturing industry is the engine of economic growth of a nation. It includes all activities in product life, starting from customer inputs for concept design, to conversion of materials and ending with product disposal. These activities provide gainful employment, create the products required to maintain and improve the standard of living and generate the wealth required for future development (Sodhi *et al.*, 2012).

India can and will transform itself into a developed nation through the growth of its manufacturing industry, but this must be achieved in a responsible and sustainable manner, creating a role model for other developing nations. Conventional prescriptions emphasizing increased technology transfers, infrastructure projects, tax incentives and R&D spending are not sufficient to ensure manufacturing competitiveness – continuous improvement in price, quality and response are needed. We therefore need a comprehensive, long-term mission and novel policies for sustainable growth of the manufacturing industry, evolved after a study of the past, present and future factors (Banawi and Bilec, 2014).

The output of an industry is a result of an efficient combination of the different factors of production (Singh *et al.*, 2013). The productivity of the industry can be measured in terms of the productivity of its constituent factors of production, such as labor and capital. However, the partial productivity measures have limitations, as in situations where capital intensity is increasing over time, partial productivity measures such as labor productivity may show an increase; however, this could be more a reflection of rising capital labor ratios rather than pure productivity increases (Chen and Lyu, 2009). This problem is resolved by analyzing total factor productivity growth, which encompasses the effect not only of the technical progress but also of better utilization of capacities, learning-by-doing and improved skills of labor (Chiarini, 2013).

3. Manufacturing sector in India

A very natural question that might arise in this regard is why manufacturing sector is so important and why to the question.

As a reaction to the colonial past, India's development strategy focused on self-reliance. In pursuit of the same, it placed a heavy emphasis on the creation of a well-diversified industrial base to realize the dream of industry-led development (Chugani and Peter, 2017). Though this strategy assigned the prime responsibility of developing heavy industries to the public sector, private sector was also allowed to play a supplemental role (Singh *et al.*, 2017). Almost until the beginning of the 80s, a myriad of measures to control the private sector, such as licensing requirement for installation of capacities, quantitative and tariff restrictions on imported inputs, regulation of monopolies and trade practices, foreign exchange regulation, nationalization of commercial banks and price control constituted an integral part of India's industrial policy (Emiliani, 2006). The socialistic fervor in the minds of policy-makers was reflected in the policy measure, such as reservation of labor-intensive manufacturing products for small-scale industries (SSIs), preferential treatment to the SSIs, and stringent labor laws against firing of labor in large firms (Galdino and Gomes, 2016). The industrial policy was primarily designed to protect the "infant" industries from external competition. Unfortunately, they had to face internal competition as well. By the end of 70s, Indian manufacturing companies suffered from high costs of production, sub-standard quality of products and lack of competitiveness of its exports. It is no surprise that the regulatory framework of the pre-1980s, *inter alia*, has been held responsible for low growth rate of output and productivity of India's manufacturing sector (Garish and Dijkshoorn, 2012).

The history of manufacturing sector in India had its origin in ancient period, the evidences of which are found from the remains of the Harappan civilization (4000–3000 BC): weights, measures, kilns and casting and metal tools; technologies for lifting loads and transportation of materials; creation of monumental architecture and ports as export points for manufactured products from smelted copper and bronze. In the milestone period 300 BC, Porus presented Alexander with 30 lbs of Indian Iron (Garza, 2015). Kautilya wrote about minerals, including iron ores and the art of extracting the metals, in *Aarthashastra*. In 350 AD, an 8-meter tall iron pillar was erected near Delhi in memory of Chandragupta II. Another 16-meter iron pillar was erected in Dhar near Indore. In 13th century, massive iron beams were used in the construction of Sun temple (Gnoni *et al.*, 2013). In 16th century, Indian steel, known as "Wootz," was exported to Middle East and Europe. In 17th century, cannons, firearms, swords and agricultural implements were manufactured. A suspension bridge was built over Beas at Saugor with iron from Tendulkhama, in the state of MP. Iron smelter was built at Porta Nova, Madras. In 1870, Bengal Iron Works was established in Kulti (Habidin and Yusuf, 2012).

The history and geography of manufacturing reveal the influence of waves of technology, local resources and conditions existing in different countries at different periods (Hajmohammad *et al.*, 2013). We also note that ancient India gave science and engineering to the world, and Medieval India was the leader in manufacture and exports of textile and metal products (Kocak *et al.*, 2017). At present, however, with less than 1% share of global trade and a poor rank in terms of competitiveness, India has to move aggressively to catch up with other nations (Hajmohammad *et al.*, 2013).The future manufacturing industry will be driven by global cooperation and intellectual property rights .Technological drivers include artificial intelligence, green materials and direct manufacturing processes. To ride these waves, new vehicles will be needed: bionics, reverse engineering, continuous innovation, knowledge management and product life-cycle engineering. These will lead to entirely new products and processes (Kocak *et al.*, 2017). The vision is to create and regenerate all types of wealth – material, natural, intellectual and cultural – by encouraging and supporting appropriate manufacturing activities that respect nature and maintain a balance among various resources (Lozzi and Hurry, 2008).

4. Lean manufacturing

Lean was developed in Toyota as part of the Toyota Production System, which was built around the work of Shewhart and Deming (Myrdal *et al.*, 2017). Toyota had been a client of Deming and established its operational management practices on the principles he taught. The fundamental driver of Lean is the elimination of waste. In fact, a good description of the Lean approach is, "a set of tools that assist in the identification and the steady elimination of waste" (Naslund *et al.*, 2017).

If a company is doing large-scale, high-quantity production like Toyota, then a process with waste in it means that company is creating large-scale, high-quantity waste. No company wants to do this. The Lean approach uses tools to analyze the business process (Oberoi *et al.*, 2008).

There are five principals of Lean illustrated below:

(1) Value: Value is determined by what the customer considers to be important within a product or service, rather than what the individuals developing or delivering the product or service consider important.

(2) Value stream: The set of business activities and steps involved in creating and delivering products and services to the customer; it is the connection of the steps together rather than considering each step in isolation.

(3) Flow: The degree to which there is smooth uninterrupted flow of activities that add value to the customer, rather than waste and inefficiency that impede the flow through the value stream.

(4) Pull: The degree to which the value stream is only processing products and services for which there is a customer demand, rather than creating something and hoping someone wants it.

(5) Perfection: The continuous assessment of value stream performance to identify and improve the value created and delivered to the customer, rather than resisting changes that improve the process of creating and delivering customer value.

5. Six Sigma

Six Sigma approach focuses on identifying and eliminating anything that caused variation in the process. When the variation is gone, the process results can be precisely predicted – every time (Oberoi *et al.*, 2008). By designing the system so that these precisely predictable results fall within the zone of acceptable performance from a customer perspective, process errors are eliminated (Ohno and Tanner, 2007).

But the engineers at Motorola went one step further. They knew from experience that many process changes were not effective because they did not get to the root cause of the problem (Shaw, 2018). Also, the changes they made would not stick, as the operators reverted back to doing things in the original manner over time. Six Sigma was organized with five phases to address these issues.

Phases of Six Sigma

(1) *Define*: In this phase, the boundaries for the process being analyzed are set, and the expectations or desired performance for that process is defined from a customer perspective. This is to ensure a change does not degrade the customer experience, but instead enhances it.

(2) *Measure*: In this phase, the current performance of the process, product or service is measured to determine what is actually occurring, especially from a customer perspective. This is to ensure the analysis and solution are based on actual performance, not theoretical or anecdotal information.

(3) *Analyze*: In this phase, the process, product or service is analyzed using the measured data to determine the source or sources of the variation that are causing the problem. This is to ensure the true root cause(s) is identified, and not just a symptom.

(4) *Improve*: In this phase, the possible changes to the process, product or service are assessed, and a solution set of changes is designed and tested. This is to ensure the solution creates the desired effect and that the variation is reduced or eliminated.

(5) *Control*: In this phase, the changes are implemented, the supporting systems are also updated and the process, product or service is put under control – normally statistical process control – to ensure the solution is fully implemented in a sustainable manner and to identify if performance starts to degrade.

The methodology of Six Sigma will work with any process, product or service that has a definable performance goal and measurable characteristics, because the methodology heavily relies on data (Sodhi *et al.*, 2014).

6. Lean Six Sigma: a clinical treatment for corona-hit manufacturing sector

There are three key elements of Lean Six Sigma:

Tools and techniques: A comprehensive set of tools and analytical techniques that are used to identify and solve problems (Sodhi *et al.*, 2014).

Process and methodology: A series of phases that organize the use of the problem-solving tools to ensure that the true root causes are found and that a solution is fully implemented (Sodhi and Singh, 2013).

Mindset and culture: A way of thinking that relies on data and processes to achieve operational performance goals and continuously improve (Sodhi *et al.*, 2012) (see Figure 1).

These three elements reinforce each other. Analytical techniques are not used effectively unless there is a process for applying them and a mindset for continuous improvement creating the need for them (Sodhi *et al.*, 2019a, b). An improvement process does not produce the desired results unless it includes the tools and techniques that define the activity of the process steps and there is a culture that insists on systemic data-based approach to solving problems.

Finally, a culture that seeks to continuously improve will be frustrated if there are no tools and techniques for analysis and no process or methodology that can be applied to organize and focus the improvement efforts. Fortunately, the Lean Six Sigma approach to business improvement includes all three layers (Sodhi *et al.*, 2019a, b).

7. Methodology adopted

This section of the study presents general outline of methodology adopted in present research work. Initial extensive literature based upon Lean Manufacturing is reviewed. From the reviewed literature, it has been observed that Lean Manufacturing is a very rarely used technique in other parts of the world, especially in developing countries. Therefore, there is a huge scope of implementing Lean technique in manufacturing SMEs to reap subsequent advantages. A questionnaire on a 5-point Likert scale was prepared to access the effectiveness of Lean Manufacturing tools implementation in Indian SMEs. Further, this questionnaire was sent to various researchers, academicians and industrial practitioners for the purpose of pilot survey and validation. After getting necessary inputs, questionnaire was finalized. This questionnaire is based upon ten questions, each on every factor of Lean Manufacturing and a total number of ten questions were prepared for evaluating the outcome of various tools of Lean Manufacturing. Step by step methodology adopted for this study is illustrated in Figure 2.

8. Describing model structure and formulation of hierarchy

Figure 3 demonstrates the aftereffects of the investigation. The degrees of Lean assembling devices in assembling associations have been demonstrated graphically. Recognizable proof of the significant qualities (Tools of Lean Manufacturing) for analytic hierarchy process

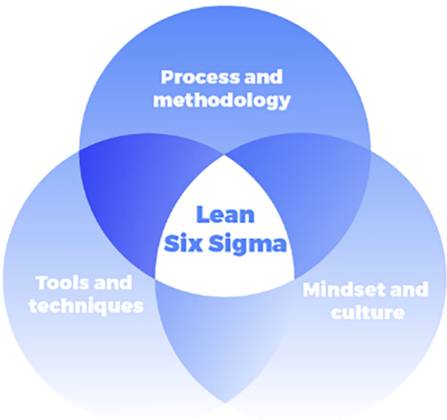

Figure 1.
Key elements of Lean Six Sigma

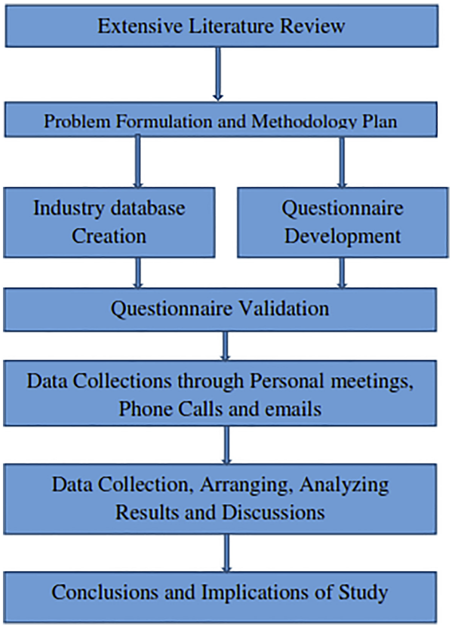

Figure 2.
Methodology adopted for the study

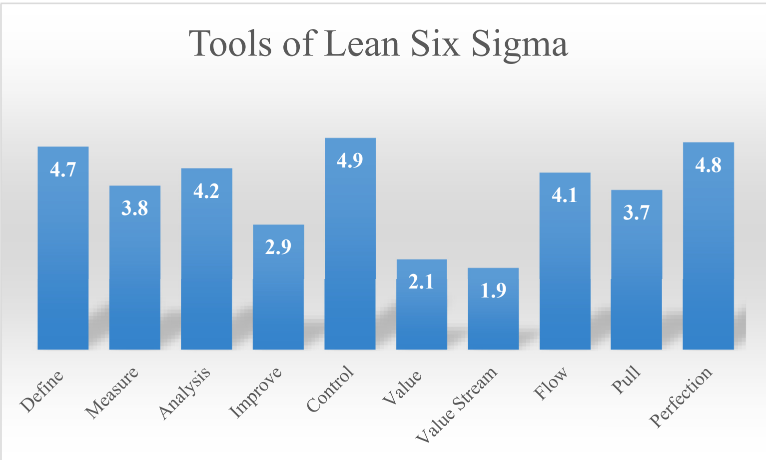

Figure 3.
Levels of Lean Manufacturing tools in manufacturing organizations

(AHP) requires an intensive investigation of the issue. For current investigation, the determination of traits has been resolved through writing study and discourses which were held with specialists during modern visits and with academicians working in a similar region. Five significant instruments of Lean Manufacturing with most elevated scores as appeared in figure have been selected, and their portrayal is given in Table 1.

Table 2 is a simple decision matrix consisting of ten criteria: Define, Measure, Analysis, Improve, Control, Value, Value Stream, Flow, Pull and Perfection. Each criteria is having five alternatives, with each alternative having its own value of criteria associated with them.

The value in the pair-wise matrix will depend upon the decision-maker or the person who is responding to the questionnaire which is circulated in the manufacturing organization. The sum of each value calculated is shown at the bottom of each column of the table. A pair-wise simple matrix is represented in Table 2, which gives relative importance of various attributes with respect to the barriers associated with the implementation of waste management technique in the manufacturing organizations.

The resulting weights are based on the principal eigenvector of the decision matrix:

9. Paired comparison of different sub-objectives

This pair-wise examination lattice is made with size of relative significance. Matched correlation depends on the possibility that a mind-boggling issue can be adequately analyzed on the off chance that it is progressively decayed into its parts. The components are contrasted with one another along these lines, giving a chance to a couple insightful correlation for developing the structure into a $n*n$ corresponding judgment network. In the lattice, one starts with a component on the left and thinks about the amount more significant it is than a component on top. When contrasted and itself, the proportion is one. When contrasted with another component, in the event that it is a higher priority than that component, a number worth, as talked about underneath, is utilized. Assuming, notwithstanding, it is less significant, at that point corresponding of the past whole number worth is utilized. In either case, proportional worth is entered in the transpose position of the framework. In this manner, just $(n–1)/2$ decisions are viewed as where n is the absolute number. In this examination, the significance of I-th sub-objective is contrasted and

Table 1.
Levels of Lean Six Sigma tools in manufacturing organizations

Attribute	Score
Define	4.7
Measure	3.8
Analysis	4.2
Improve	2.9
Control	4.9
Value	2.1
Value stream	1.9
Flow	4.1
Pull	3.7
Perfection	4.8

Table 2.
AHP matrix for Lean Six Sigma Tools

	1	2	3	4	5	6	7	8	9	10
1.	1	5	8	1	4	9	2	8	7	6
2.	0.2	1	5	4	8	2	9	7	2	9
3.	0.12	0.2	1	5	7	3	4	4	1	9
4.	1	0.25	0.2	1	8	7	6	8	3	5
5.	0.25	0.12	0.14	0.12	1	9	6	4	5	3
6.	0.11	0.5	0.33	0.14	0.11	1	9	5	1	4
7.	0.5	0.11	0.25	0.17	0.17	0.11	1	9	7	2
8.	0.12	0.14	0.25	0.12	0.25	0.2	0.11	1	4	2
9.	0.14	0.5	1	0.33	0.2	1	0.14	0.25	1	7
10.	0.17	0.11	0.11	0.2	0.33	0.25	0.5	0.5	0.14	1

j-th sub-objective is determined. A size of 1 to 9 is utilized for giving judgment esteem as indicated by the accompanying rules: = 1l if i and j are equally important.

= 3 if i is weakly more important than j.

= 5 if i is strongly more important than j.

= 7 if i is very strongly more important than j.

= 9 if i is absolutely more important than j.

Value of 2, 4, 6 and 8 are used to compromise between two judgments. The length of pair-wise matrix is equally equivalent to the number of criteria used in decision-making process.

9.1 Checking for consistency

The weight periods of the highlights are gotten by figuring the eigenvector loads for the judgment network. A file of consistency is determined to give data on how genuine is infringement of numerical and transitive consistency. The outcomes could be utilized to look for extra data and reconsider the information utilized in building the scale so as to improve consistency. The relative loads, which would likewise introduce the eigenvalues of criteria, ought to be checked (see Tables 3 and 4):

$$A \times Wi = \lambda \max \times W \qquad i = 1,\ 2,\ \ldots,\ n$$

The consistency list (CI) is = (λ max I–n)/(n–1), where n is the quantity of components being thought about and λ is the largest eigenvalue of the judgment grid. Partitioning CI by the arbitrary consistency number for a similar size network, consistency proportion CR can be acquired. The estimation of CR ought to be around 10% or less to be worthy. At times, a most extreme estimation of 20% might be endured. On the off chance that CR is not within this range, members should consider the issue and update their judgment. The normal textures for various request irregular frameworks are given below.

10. Results and discussions

Table 5 represents the weights of individual tools of Lean Six Sigma which may be considered by the floor manager while considering the Lean Six Sigma implementation for waste management. After calculating AHP of various tools of Lean Six Sigma Manufacturing, it has been observed that defining the problem adequately is the top priority among all tools of Lean Manufacturing, with a priority score of 25.7%; it has been ranked at number 1. Measure is categorized at second rank, with a priority score of 20%. At the same time, analysis is having a percentage priority of 13.8%, and it has been ranked at number three among all the tools of Lean Six Sigma in manufacturing. Perfection has a percentage priority of 1.3%, and it has been categorized at the last rank among all considered Lean Six Sigma Manufacturing tools.

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.42	1.45	1.49

Table 3. Random consistency index (RI)

Max eigenvalue λ max	Consistency index	Random consistency index	Consistency ratio
Values	0.421	1.33	0.032

Table 4. Results of consistency test

Table 5.
Ranking of lean six sigma tools

Cat		Priority	Rank	(+)	(−)
1.	Define	25.70%	1	24.00%	24.00%
2.	Measure	20.00%	2	16.80%	16.80%
3.	Analysis	13.80%	4	15.70%	15.70%
4.	Control	14.30%	3	13.10%	13.10%
5.	Improve	8.60%	5	10.40%	10.40%
6.	Value	5.80%	6	8.10%	8.10%
7.	Value stream	4.80%	7	5.50%	5.50%
8.	Flow	2.20%	9	2.50%	2.50%
9.	Pull	3.50%	8	2.80%	2.80%
10.	Perfection	1.30%	10	0.70%	0.70%

11. Conclusions

Manufacturing industries are the worst affected from coronavirus. Hence, the need of the hour is to suggest some of the techniques to the industrial experts to recover from this situation. Therefore, in the present research article, it has been suggested that the manufacturing industries should implement Lean Six Sigma tools and techniques in order to recover from the after-effects of the coronavirus. Proper management of waste among manufacturing organizations is one of the biggest challenge faced by the industries nowadays. Lean Manufacturing is one of the solution for adequate waste management. In the present study, ranking or prioritization of various tools of Lean Manufacturing has been done using analytic hierarchy process (AHP). After calculating AHP of various tools of Lean Manufacturing, it has been observed that define and measure are the most preferred phases of implementation.

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Corresponding author

Harsimran Singh Sodhi can be contacted at: harsimransinghsodhi@yahoo.com