An Empirical Study on Lean Performance Parameters of Manufacturing Sector

Lokesh Vijayvargy\textsuperscript{1} and Srikant Gupta\textsuperscript{1}

\textsuperscript{1}Jaipuria Institute of Management, Jaipur, India

E-mail: lokesh.vijayvargy@jaipuria.ac.in

Abstract. Growth and GDP of any nation is depend on its in-house manufacturing capacity. Due to manufacturing many countries like: China, Japan, USA, and Korea are leading world in growth and employability. But due to low cost and govt. policy, India is one of the most lucrative option for manufacturing industry to prosper. This paper will help us in identification of lean performance parameters of manufacturing companies in India. Data were collected in form of questionnaire by managers of 100 manufacturing firms to identify various lean performance parameters. Sample of manufacturing industry are like agriculture tools and equipment’s, Material handling equipment’s, Parts of various machines parts and construction machines and parts, bolts and nuts, etc are included in our research. The respondent has different position in organization like HR manager, operations manager, SCM manager, owner, director, etc. To identify parameters of lean performance, this study used statistical tools. The outcomes of the research work offer the important implications for the Indian manufacturing organizations to understand the factors affecting their performance.

1. Introduction

Growth and GDP of any nation is depend on its in-house manufacturing capacity. Due to manufacturing China, Japan, USA, and Korea are leading world in growth and employability. But due to low cost and govt. policy, India is coming with new emerged area for manufacturing hub in world. India has launched many strategies to increase investmeent and employability in manufacturing sector like: Make in India, Startup India, and Digital India etc. The success of these strategies on lean performance of manufacturing sector in India. The lean performance of manufacturing sector depends on its efficiency, product quality, cost of product, productivity, etc [1].

Lean operations, often simply “Lean is a systematic method for waste minimization within a manufacturing system without sacrificing productivity, which can cause problems” [2]. Lean also takes into consideration of waste caused by overload and waste produced by workload patchiness. The Indian manufacturing sector plays an integral part in the Indian economic development and is a major contributor to the country’s GDP @16% as of now. The manufacturing sector in India is a driving force for many other industries in the country. At present, the Indian manufacturing sector deals in 4 major types of products:

- Basic goods (cement, steel, etc.)
- Capital Goods (machine tools, wagons, etc.)
- Intermediate goods (cotton yarn, petroleum, etc.)
- Consumer Goods (wheat flour, tea, etc.)

The world’s largest producer of textiles, chemical and pharmaceutical goods, essential metals, equipment, and energy is currently in India, with exceptions from CHINA according to UNIDO. The
reason behind the tremendous growth in the past few has been a shift in the manufacturing sector from a public sector to a more privately owned enterprise with global ambitions. There has been a high growth trajectory in this sector and National Manufacturing Competitive Council has projected the growth in the contribution to GDP by this sector is 25% by 2025. The estimated growth has been supported by the government of India. It has set up technology parks with electronic hardware, special economic areas and has also reserved a prosperous future for foreign investors through FDI. With liberalization and relaxed tariffs & duties, the sector is being promoted. In addition to this, government has given the nod to Modified Special Incentive Package Scheme which offers up to US$ 1.7 billion benefits to the electronics sector in the next 5 years, it being a growing industry in India. It’s association to the strength of the Indian domestic market is commendable. Another booming sub-sector of the Indian Manufacturing Sector is the increase in investment by international players in terms of setting plants in India which includes Hyundai, Airbus, Nokia, Samsung, etc... This shall increase the labor absorption in the country by the manufacturing sector which currently stands @ 12%. With such scope from one sector of the economy, it becomes important for the government to harness the same and push it to its full potential. The reasons as to why this sector should be pushed can be derived from the statistics that have been drawn so far. Such as:

- The rise of the domestic economy, the second largest consumer market worldwide by 2030, is projected to expand the potential for this industry to grow.
- With a youth population of around 60%, the industry can reach its potential within the next 2 decades. This is because young workforce that is goal driven is an asset.
- The “Make in India” campaign and other such sector specific incentives will make India a manufacturing hub very soon.
- India being a resource rich nation, can easily take down the major costs with the use of renewable energy sources which includes solar power and hydro power capacities. This will make the growth of manufacturing sector sustainable.

With all stats and growth prospects in place, it becomes important for the government to move forward with various policies that promote entrepreneurship in this area so that the contribution to GDP can be maximized and the country’s manpower is fully employed. For making India as leading industrialized nation in the world, Indian Manufacturing sector is required to measure their performance time to time on different parameters. So that, they can reach at lean and agile process and achieve maximum efficiency in world. Only manufacturing sector can make India from underdeveloped nation to the developed nation. Therefore, this study is analyzed performance of manufacturing sector on various parameters.

After Maharashtra and Gujarat, Rajasthan is one of India's leading investment destinations for its quiet surroundings and improved law and order, outstanding infrastructure, a favourable investment climate and very low population density. Rajasthan have various sector like: automobile, electronics, process industry, M/C & tools industry, agri-process units, textile and Marbles industry. These industries are providing lots of employability. But there are facing many problems in today like; increasing in cost, decreasing productivity, lack of flexibility, increased lead time, decreasing trend of product demand etc. These problems occurred due to lack in measurement of operational performance on various parameters. Therefore, this paper will give detail analysis on various variables which influencing operational performance of any manufacturing sector. The objective of the study is to identify influencing parameter which impact operational performance of any lean manufacturing industry. The study aims to identify various lean performance parameter which lead business performance.

The rest of the paper is organized as follows: section 2 contains literature review related with lean theory, research methodology has been presented in section 3 while the data analysis and discussion part have been summarized in section 4 and 5 respectively. Finally, conclusion of the whole work is given in section 6.

2. Literature Review
The ever-changing global climate has raised sustainability and survival problems for all manufacturing sectors. Manufacturers are continually undertaking modifications and enhancements in their main
operations or procedures to address their challenges. Lean operations are focused on innovation and creativity in process which lead waste reduction, minimizing variations and thereby facilitating cost reduction [3]. Studies were also done to identify various factors such as quality, productivity, speed and flexibility which lead to a successful lean implementation. This study evaluates the same, using the lean success factors which are selected based on the literature review. That helps to define the core reasons for the effectiveness of lean production in the sense of production, by any manufacturing business that implements or expects to adopt lean theory. By using the interpretive structural modelling, the multiple enablers of Lean implementation in the manufacturing industry have been identified by Sharma et al. [4] and ranked them by using the interpretive ranking process. Wickramasinghe and Wickramasinghe [5] studied the impact on production efficiency of lean production methods and lean time (time of service of Lean Production). The results showed that lean production activities dramatically increase production output and showed that the period of lean production during operations is necessary to achieve higher levels of production quality. Singh et al. [6] highlighted the use of lean practices by explaining how it would deliver the genuine achievements in cost saving in the automotive sector. The findings clearly demonstrate that the most critical aspect of lean production is just-in-time delivery [7].

The biggest manufacturing challenge is to manufacture more goods with less material, less resources and less labour, according to Chryssolouris et al. [8]. In order to make more strong pillar for growth of any nation. Operational Performance is one of major indicator of measuring overall performance of any firm. Performance system of firm aims to identifying success and failed information with help of various indicator like: productivity, Inventory, Lead time, quality and etc. Which help to take decision for future and diagnose problems. There are several studied carry out for measure operational performance of firm. Dieste et al. [9] outlined the environmental interventions that have a positive effect on lean practices (value, value stream mapping, flow, pull and continuous improvements), and emphasized the core lean practices with respect to environmental impacts. Singh et al. [10] identified key performance indicators for assessing the impact of green-lean activities in the manufacturing industries. The primary objective of this study is to achieve and optimize efficiency using key performance indicators to allow Green-lean concepts to be developed within the manufacturing sector. Raval et al. [11] studied Lean Tools/Technologies for the Indian Manufacturing Organization, with the goal of tracking organizational results, and proposed methods to benchmark operating productivity in the enterprise. The study not only explores the optimal input level but also indicates that an enterprise with a higher profit / investment turnover ratio is not inherently an effective organization. Table 1 is representing comprehensive literature review on operational performance indicators.

**Table 1. Comprehensive Literature on Performance of Manufacturing Sector**

| Authors               | Finding                                                                                                                                 |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Belekoukias et al.    | Effectiveness, Lead Time and SCM Practices are crucial indicators for operational performance of manufacturing firms                           |
| Sraun and Singh       | Quality relate variables like TQM, 5S, JIT etc. are positive indicators of lean operational performance.                                      |
| Garbie [14]           | Product cost, system productivity, response time, inventory and etc. are the part of measurement of operational performance.                |
| Ghosh [1]             | Lean performance will improve by TQM, JIM, SQC, Kaizen, Quality Circle, reduced inventory etc.                                             |
| Sahoo and Jena [15]   | Define various performance indicators and sub indicators for manufacturing sector.                                                        |
| Kumar and Gulati [16] | There is strong relationship between effectiveness and operational performance in banking system which lead efficiency.                   |
| Gomes al et. [17]     | He analyzed operational performance by utilization, flexibility, efficiency and information of 79 Portuguese manufacturing firms. He found strong relationship between all the factors with operational performance. |
| Dangayach and         | Quality, productivity and innovation parameters are major focus area of Indian manufacturing industries.                                 |
Deshmukh [18] manufacturing sector to lead lean and agile process

Table 1 indicates that researchers have based their attention mainly on empirical research in order to explain the ties between variations with organizational efficiency. Ghosh [1], and Srauti and Singh [12] suggested that quality is main parameter for performance of an organization while Gomes [17] and Karim and Zaman [19] found effectiveness, efficiency and delivery time are crucial indicators of operational performances. Lal [20] study suggested that competitiveness of any firm will depend on efficiency and adoption of e-business tool. There is no clean picture for performance indicators of any firm and integrate model of these factor. Based on literature, the study identified seven variables for lean operational performance (LOP). Singh et al. [21] showed the necessity for researching lean practices, including Kaizen and innovation management practises in the field of business sustainability. Udokporo et al. [22] and Vijayvargy et al. [23] investigated the relationship between the lean, agile and green and productivity of firms and focused on more sources of improvements in indicators of productivity expense, lead time and production cycle [24]. The figure 1 and table 2 represent the model of LOP which consist of productivity, quality, lead time, flexibility, inventory, efficiency, and effectiveness.

![Figure 1. Model for Lean Operational Performance](image)

**Table 2. Definition of Lean Operational Performance**

| Performance Parameter | Definition |
|-----------------------|------------|
| Productivity          | Productivity is defined as the output related to the input given. |
| Efficiency            | Efficiency is defined as the ratio of useful work performed by a machine. |
| Effectiveness         | Effectiveness is defined as the degree something can produce desired result. |
| Quality               | Quality can be defined as the standard of something as measured against similar things. |
| Inventory             | Inventory can be defined as the total amount of asset hold by the company. |
| Lead Time             | Lead Time is the time between initiation and completion of production process. |
| Flexibility           | The ability of organization to resist changes in a good manner. |

*Schonberger [24]*
3. Research Methodology

Sociologists use a combination of qualitative and quantitative methods of analysis, including tests, study research, observation of subjects, and secondary evidence. Quantitative methods aim to classify features, count them, and create statistical models to test hypotheses and explain observations. Qualitative methods aim for a complete, detailed description of observations, including the context of events and circumstances. In the research we developed a questioner asking the respondent to give us details about productivity, effectiveness, quality, inventory, process, problems faced in manufacturing and also covered different other aspects. We surveyed 100 different manufacturing firms for the same and then figured out how the manufacturing industry in Rajasthan.

3.1 Objective

Every day, producers generate vast numbers, all of which directly or indirectly influence customers meet. As every sector, the automotive industry has priorities and plans intended to increase the bottom line of a business. These relate to quality, safety, vendor selection, problem identification and resolution, and efficiency and costs. The objectives are following:

- To find lean performance parameters for manufacturing companies
- To know about how the manufacturing sector deals with flexibility and lead time.
- To know relationship between various parameters of lean performance

3.2 Questionnaire Development

This questionnaire is designed with 3 sections. Section A is designed to gather general information about the respondent. In Section B information regarding importance of productivity, effectiveness, lead time, quality, flexibility, inventory in manufacturing industry. This category has factors like latest technology, price, better quality, quality etc. In Section C about statements on layout of the organization which was surveyed, and the problem faced by it in manufacturing. View regarding the level of practice implementation were rated a five-point, ranging from 1= Not at all important, 2=minor important, 3=average important, 4=important, 5= extremely important.

4. Data Analysis

The fig 2 shows that how many worker work in manufacturing company. According to above graph we can say that 58.57% manufacturing company have less than 100 employees in their organization. Our sample size of research is more than 70 and in this data 41 company used less than 100 employees. Only 5.71% company have employees in range of 1000-2000. The fig. 3 is related to organization annual turnover. In more than 70 organizations 41 organization have less than 100 crores annual turnover. While only 3 organizations which are having annual turnover between 1000-2000 crore. There is 4 manufacturing organization which are having more than 2000 crore Rs. annual turnover.

![Figure 2. No. of Employee in Organization](image)

![Figure 3. Turnover of Company](image)

The figure 4 shows the factor which is more important for company and they try to maintain it. According to our result 94.29%, company says we are focus on productivity. While 88.57% company focus on quality which lead to lean performance.
To check reliability of data, the reliability test was performed to find cronbach’s alpha value. The reliability for all the lean performance parameters is found greater than acceptance limit (>0.6), the alpha values are 0.93, 0.90, 0.79, 0.85, 0.83 and 0.80 for productivity, effectiveness, lead time, quality, flexibility and inventory, respectively. Thus, the data are acceptable for further analysis.

Table 3. Descriptive Statistic of Performance Parameters

| Parameters   | Mean | Standard Deviation | Kurtosis | Skewness |
|--------------|------|--------------------|----------|----------|
| Productivity | 4.54 | 0.65               | 0.10     | -1.11    |
| Effectiveness| 4.00 | 0.86               | -0.23    | -0.58    |
| Lead time    | 3.81 | 0.97               | 0.59     | -0.79    |
| Quality      | 4.77 | 0.46               | 2.25     | -1.76    |
| Flexibility  | 3.38 | 1.18               | -0.38    | -0.56    |
| Inventory    | 3.57 | 0.85               | -0.59    | 0.09     |

Table 3 shows descriptive statistics of the considered performance parameters. Among them, the mean value of the quality is found to be higher than all the considered performance parameters. Figure 5 shows current situation of implementation of quality management in organization. In India, many quality management tools used by company like Just in time, 5S, kaizen etc. In India, 32% company used Just in Time quality management tool, which is very useful to reduce cost. Most of company used TQM. In addition, 5S, kaizen, six sigma are famous method for quality management.

In order to test the relationship between performance indicators and lean performance, the bivariate Spearman rank coefficients is carried out and the results are summarised in Table 4.
Table 4. Correlation Matrix

| Productivity | Effectiveness | Lead Time | Quality | Flexibility | Inventory | Lean Performance |
|--------------|--------------|-----------|---------|-------------|-----------|------------------|
| Productivity | 1            |           |         |             |           |                  |
| Effectiveness| 0.320        | 1         |         |             |           |                  |
| Lead Time    | 0.414        | 0.588     | 1       |             |           |                  |
| Quality      | 0.351        | 0.727     | 0.724   | 1           |           |                  |
| Flexibility  | 0.348        | 0.833     | 0.689   | 0.740       | 1         |                  |
| Inventory    | -0.019       | 0.284     | 0.150   | 0.260       | 0.343     | 1                |
| Lean Performance | 0.329 | 0.123 | 0.018 | 0.081 | 0.035 | -0.092 | 1 |

Table 4 shows that there is a positive linkage among the performance indicators i.e., productivity, effectiveness, lead time, quality, and flexibility with lean performance and while negative with inventory. The most robust linkage is found between flexibility and effectiveness, which exhibits a correlation coefficient of 0.83. Furthermore, the correlation result indicates that there is a negative correlation between the performance indicators like inventory and productivity, and lean performance with inventory. Based upon the literature review, the theoretical context and the framework, the following hypothesis have been constructed:

- **H0a:** There is no positive linkage between lean performance and the level of productivity.
  
  V/s
  
  **H1a:** There is a positive linkage between lean performance and the level of productivity.

- **H0b:** There is no positive linkage between lean performance and the level of effectiveness.
  
  V/s
  
  **H1b:** There is a positive linkage between lean performance and the level of effectiveness.

- **H0c:** There is no negative linkage between lean performance and the lead time.
  
  V/s
  
  **H1c:** There is a negative linkage between lean performance and the lead time.

- **H0d:** There is no positive linkage between lean performance and the level of quality.
  
  V/s
  
  **H1d:** There is a positive linkage between lean performance and the level of quality.

- **H0e:** There is no positive linkage between lean performance and the level of flexibility.
  
  V/s
  
  **H1e:** There is a positive linkage between lean performance and the level of flexibility.

- **H0f:** There is no negative linkage between lean performance and the level of inventory.
  
  V/s
  
  **H1f:** There is a negative linkage between lean performance and the level of inventory.

Furthermore, regression analysis is conducted to test the impact of different performance indicators and lean performance in table 5.
Table 5. Regression Matrix

| Independent Variables | R²       | F Statistic | p-Value (F Test) | Coefficients | t-Value | t-test p-value |
|-----------------------|----------|-------------|------------------|--------------|---------|----------------|
| Productivity         | 0.115845424 | 19.52256833 | 0.000            | 3.334464671  | 4.418435054 | 0.0000190     |
| Effectiveness        | 0.027815769 | 4.263131935 | 0.000            | 3.52060777  | 2.064735318 | 0.040681464   |
| Lead time            | 0.025855554 | 3.954588    | 0.000            | 3.53325849  | 1.988614498 | 0.048575226   |
| Quality              | 0.026951241 | 4.12691434  | 0.000            | 3.085076046 | 2.031492415 | 0.043982456   |
| Flexibility          | 0.026872079 | 4.114505104 | 0.000            | 2.869507763 | 2.028424291 | 0.044298324   |
| Inventory            | 0.065311238 | 10.41135278 | 0.000            | 4.464739198 | -3.22666  | 0.001539955    |

The regression test indicated in Table 5 that different performance indicators are statistically significant to the lean performance. The results of correlation analysis, and regression analysis suggest that hypotheses H1a, H1b, H1c, H1d, H1e and H1f should be accepted.

5. Discussion

Analysis suggested many time that manufacturing organization faced problem related to ordering process. The problem may be like loss of order, fax not received, not a good definition of what is wanted etc. which effect organization productivity and efficiency. Some more observations of study are:

- 78% believe technology can be game changer factor for operational performance.
- 48% visit the store and 28% work on online mode
- 46% said order loss due to unavailability of material and 26% due to poor communication with supplier
- 80% believe quality is very important but
  - 62% have quality manual
  - 48% follow procedures of quality management
  - 43% implemented quality management practices

Lean management process are no longer confined to a specific field of industrial businesses. Both large and smaller manufacturer uses lean performance process to boost their efficiency and reduced the costs of the system. With quality enhancement, less deficient or defective goods are produced, and if waste is reduced and thus it also helps in reducing the costs. Lean performance indicators emphasis on the removal of waste from business operations and the movement of goods or services through faster with less waiting time. With the minimization of waste, the manufacturer can do more with little to no additional work-force and money, and thereby increase the efficiency in production. This study indicates the positive linkage between the lean performance with productivity, effectiveness, lead time, quality, and flexibility while negative linkage with inventory. The relation between the inventory leanness and performance in the industrial industry was found to be non-linear. This means that lean stock can be associated with efficiency to a growing degree, and a diminishing positive or negative association with performance in a variety of inefficient inventory levels. For a variety of factors, this observation is technically significant. First, it suggests that investment and lean inventory efforts can result in lower returns after hitting a threshold stage. In other words, the leaner inventory is no safer in terms of financial results until maximum inventory leanness has been attained. Firms will achieve higher ability to meet customer’s flexibility needs if they focus strongly on these indicators. Therefore, company should improve their process to achieve lean performance by enhancing the different performance indicators. Lean is a massive and global process in the manufacturing industry, and it is not easy to incorporate all the performance indicators all together for improving the lean performance.
6. Conclusion
Lean manufacturing is a set of strategies intended to reduce material and labor effort while retaining or increasing output levels, which contributes to a net gain in overall efficiency. The empirical study was used in this study to examine the importance of lean performance for operational efficiency. The study found productivity, effectiveness, inventory are the major aspects of operational efficiency. Organizations are using various quality tools and techniques like six-sigma, KAIZAN, just in time, etc. to enhance lean performance and quality of product. Lean operations have a linear effect, enhancing operating effectiveness, organizational productivity, quality, and performance. The outcome of the study concludes that Lean operations parameters is helpful in improvement of overall competitiveness of Indian industry to overcome the global competition with make sustainable growth and development. While the research fulfills its goals, some limitations must be accepted to generalize its results. Firstly, it is an observational analysis and the complex essence of sustainable performance is missing from the study. A research is expected in future to better understand to what degree lean manufacturing practices impact sustainability performance.

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