Lean Manufacturing Adoption and Its Impact on Productivity in MSMEs Evidence from GIDC Industrial Estates, India

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ABSTRACT

The lean manufacturing method, which originated from the Toyota Production System, is based on improving production efficiency by eliminating processes that do not add value and continuously optimising the workflow. While the lean manufacturing method appears to be widely adopted by large companies, reliable information on its actual implementation and impact on performance in small and medium-sized enterprises (SMEs), especially those in emerging industrial areas, remains lacking.

This study aims to investigate the extent to which small and medium-sized enterprises (SMEs) on the Gujarat Industrial Development Corporation (IDC) campus in India have adopted lean manufacturing methods and their impact on production efficiency. Combining descriptive and analytical methods, raw data were collected from 30 participants through questionnaires, interviews, and field observations. Secondary sources, such as government reports and literature on lean manufacturing, were also consulted. This study focuses on methods such as 5S, Kaizen, Just-in-Time (JIT), Total Productivity Management (TPM), Kanban, and Value Stream Mapping (VSM), and analyses the relationship between these methods and productivity indicators such as output per employee, cycle time, defect rate, machine utilization rate, and overall equipment efficiency (OEE).

The results of this study, statistically significant, suggest that the adoption of lean management certainly contributes to increased productivity. This is a positive sign. While basic methods such as 5S and Kaizen are relatively widespread, more advanced tools are still not fully adopted. However, several challenges remain, including a shortage of skilled workers, employee resistance to change, insufficient training, funding issues, and delays in the full-scale implementation of lean management by management.

This adds new practical evidence to the literature demonstrating that lean management is an effective way to improve operational capabilities, particularly for small and medium-sized enterprises (SMEs) in such clusters. Training programs, strengthened leadership responsibilities, and supportive policies are especially important for the continued adoption of lean management in these small businesses. While the above analysis may be somewhat simplified, generally speaking, this is true.

Keywords: Lean Manufacturing, MSMEs, Productivity, Operational Performance, Continuous Improvement, GIDC, Emerging Economies.

INTRODUCTION

Lean manufacturing, originating from the Toyota Production System, focuses on eliminating waste in factories and making production processes smoother and more efficient. Waste includes overproduction, long waiting times, inventory buildup, production interruptions due to product defects, and unnecessary handling. The goal of lean manufacturing is to utilize resources more effectively by focusing on processes that truly create value and avoiding unnecessary delays.

In industrial clusters like the Gujarat Industrial Development Corporation (GIDC), small and medium-sized enterprises (SMEs) face significant challenges. Raw material prices continue to rise, customers demand higher quality and faster delivery, and competition is extremely fierce. While lean manufacturing appears to be an effective means of improving productivity, it is not widely adopted in these companies, and where it is, it remains at a basic level, with its application varying greatly by region. Therefore, this paper examines the current status of lean manufacturing

adoption, its impact on performance, and the factors hindering its implementation.

Tools used in lean manufacturing include 5S (Sort), Continuous Improvement (Improvement), Just-in- Time (avoiding inventory buildup), Integrated Maintenance (ensuring the normal operation of machinery), Kanban (process control), and Value Stream Mapping (analysis of all processes). This system, originating in Toyota, aims to reduce waste and improve productivity by covering all aspects from material handling to operational efficiency. While some aspects may not be fully explained, its core principle is to eliminate waiting times and inventory buildup through continuous optimization.

Overall, companies are increasingly focusing on lean manufacturing methods to maintain their competitiveness in manufacturing, particularly small and medium-sized enterprises (SMEs) facing management challenges. Since this approach is not yet fully implemented at the Industrial Development Centre (GIDC), it is important to examine its relevance to productivity performance. While challenges certainly exist, I believe that if more companies adopt lean manufacturing methods, it will lead to improvements in efficiency and product quality.

Problem Statement

While Lean principles are broadly documented, empirical evidence on their implementation level and measurable productivity impacts in MSMEs within emerging industrial clusters in developing countries remains limited. This gap is especially relevant for GIDC industrial estates, where a large number of MSMEs operate across engineering, plastics, chemicals, fabricated metals, automotive ancillaries, and light manufacturing.

Research Objectives

1. To evaluate the level of Lean Manufacturing adoption among MSMEs in Gujarat.
2. To identify key Lean practices (5S, Kaizen, TPM, VSM, JIT) influencing productivity.
3. To analyze the relationship between Lean implementation and productivity indicators.
4. To study barriers and challenges faced by MSMEs during Lean adoption.
5. To provide actionable recommendations for enhancing productivity through Lean tools.

Scope and Significance

The Toyota Production System, developed in Japan to increase productivity and reduce waste in manufacturing, served as the model for lean manufacturing. Techniques for removing non-value-added tasks and optimizing workflows were introduced by innovators such as Taiichi Ohno. Lean principles prioritize pull-based production systems, standardized processes, continuous improvement (Kaizen), waste reduction, and quality assurance from the start. From a method developed especially for the automotive sector, it has developed into a more general management concept that can be used to improve competitiveness, quality, and productivity in both the manufacturing and service sectors.

Lean in MSMEs

Unlike large enterprises, MSMEs may lack formal process documentation, stable production planning, and dedicated improvement teams. Evidence in the literature commonly indicates that MSMEs adopt visible Lean tools (e.g., 5S, Kaizen) more easily than system-level tools (e.g., JIT integration and VSM-based redesign). MSMEs may achieve quick initial gains but struggle to sustain improvements without leadership continuity and structured training.

Lean Tools Considered in This Study

- 5S: Workplace organization (Sort, Set in order, Shine, Standardize, Sustain).
- Kaizen: Continuous incremental improvement involving employees.
- JIT: Producing only what is needed, when needed; reduces inventory and lead time.

- TPM: Maximizing equipment effectiveness through preventive maintenance and operator involvement.
- Kanban: Visual pull system controlling WIP and replenishment.
- VSM: Mapping material and information flow to identify waste and improvement Opportunities.

Productivity Measures

This study uses operational productivity indicators: output per employee, cycle time, defect rate, machine utilization rate, and OEE (a composite of availability, performance, and quality).

Research Gap

Many Lean studies focus on large firms or mature industrial ecosystems. There is limited empirical work combining Lean adoption maturity measures and statistically tested productivity outcomes for MSMEs located in emerging industrial clusters such as the GIDC estates.

I. LITERATURE REVIEW

Ohno, T. (1988), Toyota Production System: Introduced the concept of continuous small improvements (Kaizen) that collectively lead to large efficiency gains in manufacturing. His work is considered foundational in lean manufacturing theory, emphasizing waste elimination and process flow optimization.

Driouach et al. (2019) investigated Lean implementation in Moroccan SMEs, focusing on 5S and Kaizen tools. Their study confirmed that Lean adoption significantly enhances productivity and quality, reducing waste and process variability. The research highlighted Lean's ability to instill continuous improvement culture even in resource-constrained SMEs, positioning it as a critical driver of competitiveness in developing economies.

Hrehova, S.J. Husár P. Lazorík P. Trojanowski (2024) The research presents a smart mobile application that combines Lean methods with PLM simulation tools and augmented reality technology to enhance process efficiency through value stream mapping. The application provides management with a tool to assess production losses through detailed analysis that uses a simulation model. The system allows managers to conduct virtual operational walkthroughs while accessing simulation models and operational statistics to evaluate the existing material value flow in the workplace which helps them make decisions and work remotely.

Aditya Kumar Sahu and Ramakrushna Padhy (2021) the research studied how Lean Manufacturing Practices (LMPs) spread through Micro Small and Medium Enterprises (MSMEs) which operate in developing countries. The study used Behavioral Reasoning Theory to study how employees in organizations show their acceptance of Lean practices. The results show that positive reasons drive both attitude development and intention formation while negative factors only impact attitude assessment. The research shows that employee perception determines Lean implementation success because behavioral elements function as essential factors in achieving successful implementation.

II. RESEARCH METHODOLOGY

The research methodology describes the organized process followed in this study, making sure the work is well-structured, dependable, and unbiased. A mixed-methods approach is employed, integrating both quantitative and qualitative methods to provide a comprehensive understanding of Lean Manufacturing implementation and its impact on productivity within small and medium-sized enterprises.

The data was obtained from both primary and secondary sources. Primary data was collected through structured questionnaires and semi-structured interviews with key professionals (production managers, CEOs, engineers, etc.)

belonging to small and medium-sized enterprises within the GIDC industrial cluster.

The survey employs a Likert scale, allowing participants to indicate their degree of agreement (such as 1 = Strongly Disagree to 5 = Strongly Agree). This allows the study to assess opinions on the use of Lean tools and how they affect productivity.

The interviews were conducted in a semi-structured format, allowing participants to provide more detailed answers while ensuring consistency in responses among participants. This approach helps incorporate practical industry insights, validate the validity of questionnaire responses, and understand the challenges faced in real-world settings.

Secondary data was collected from research journals, industry reports, books, and reliable online resources to reinforce the theoretical foundation and provide background information for the study.

Participants were selected from small and medium-sized enterprises using a sampling method, and the sample size was determined based on participant accessibility and suitability for statistical analysis. In this study, key factors were analysed with lean manufacturing methods (5S, Kaizen, Integrated Production Maintenance, Value Stream Mapping, etc.) as independent variables and productivity performance indicators (efficiency, cycle time reduction, machine utilisation, cost reduction, etc.) as dependent variables.

To analyse the data, a variety of statistical techniques were employed, such as descriptive statistics, correlation analysis, and regression analysis, alongside software tools like SPSS and Microsoft Excel. These methods are instrumental in testing hypotheses, exploring the relationships between variables, and formulating insightful conclusions.

In addition, the paper points out some limitations of the study like small sample size, response bias, and lack of generalisation to other MSMEs except the ones selected. However, through implementing various methods, the study tries to maintain the data's accuracy, validity, and reliability.

In brief, this methodology fits the research goals perfectly and offers a good mix of quantitative and qualitative approaches that significantly increase the study's trustworthiness and relevance.

III. THEORETICAL FRAMEWORK

The theoretical framework sets the conceptual base for the research by merging well-known theories and models on Lean Manufacturing and operational performance. It shows the basic principles on which the research variables are built and explains the rational connections between Lean methods and productivity results in small and medium-sized enterprises.

This research adopts the mindset of Lean Manufacturing, which is primarily aimed at waste elimination, continuous improvement (Kaizen), and value creation. Lean philosophy points out the removal of non- value-added activities in all processes as the path to higher efficiency, lower costs, and an overall better performance. The main Lean instruments for this framework are 5S, Kaizen, Total Productive Maintenance (TPM), and Value Stream Mapping (VSM).

Within the schema of analysis, Lean tools are thought to be independent variables, while the productivity performance dependent variable. The productivity performance is measured by several indicators including operational efficiency, production cycle time, machine utilization, and cost reduction. The premise of the framework is that increased implementation of Lean practices results in better productivity outcomes.

Moreover, the study takes into account some organizational factors such as the size of the company, the level of employee skills, the support of management, and financial resources as moderating variables since these factors might affect the success of Lean implementation and the degree of its impact on productivity.

On the other hand, the theoretical underpinnings also rely on the ideas of continuous improvement theory, systems thinking, and operational efficiency models, which together reinforce the link between process optimization and performance improvement. Incorporating these theories with real-time applications in MSMEs, the framework acts as a solid foundation for forming hypotheses and carrying out empirical investigations.

To sum up, this theoretical framework not only guides the data collection and analysis but also is deeply rooted in the principles that have been well recognized academically. It helps to establish the credibility of the study and makes its findings more valuable by connecting academic theory and actual industrial practices.

IV. HYPOTHESES

Hypotheses are testable propositions that come from the theoretical framework and literature review. They specify the expected interactions between the main variables, mostly concentrating on the level of Lean Manufacturing adoption, its influence on productivity, and the difficulties hindering its execution in MSMEs.

Hypotheses enable turning research goals into quantifiable and statistically verifiable formats. They give a concrete roadmap for data interpretation. A hypothesis always has two versions, the null hypothesis (H_0), which denies any substantial link or impact, and the so-called alternative hypothesis (H_1), which proposes a significant link or impact.

1. Lean Adoption Level

This hypothesis assesses the level of implementation of Lean Manufacturing methods in the MSME sector of Gujarat.

H_{01}: No significant level of Lean Manufacturing adoption exists among MSMEs in Gujarat. H_{11}: A significant level of Lean Manufacturing adoption exists among MSMEs in Gujarat.

2. Lean Tools and Productivity

This hypothesis investigates whether the application of individual Lean tools reflects in the productivity level of MSMEs.

H_{02}: Lean tools individually (5S, Kaizen, TPM, VSM, JIT) have no significant effect on productivity of MSMEs. H_{12}: Lean tools individually (5S, Kaizen, TPM, VSM, JIT) have significant effect on productivity of MSMEs.

3. Lean Implementation and Barriers

hypothesis attempts to reveal whether MSMEs experiencing Lean implementation is a problem for them or not.

H_{03}: MSMEs do not undergo any considerable barriers while the implementation of Lean Manufacturing practices.

H_{13}: MSMEs undergo various barriers during the implementation of Lean Manufacturing practices.

V. DATA ANALYSIS

The data analysis section discusses the steps and methods followed while analyzing the acquired data to understand the Lean Manufacturing implementation at the same time the resulting productivity increase in MSMEs.

Initially, the raw data was cleaned and formatted to make sure that both correctness and uniformity were preserved. The refusals that were not filled up, the absent parts, as well as the unusually high or low values, were carefully examined and the right decisions made for each case, so that the most trustworthy data is kept in the final set. The answers given through the questionnaires based on the Likert scale were coded and changed into numbers to make it easier to analyze quantitatively, whereas the responses coming from the open-ended questions and the interviews were neatly arranged and analyzed qualitatively.

Using quantitative analysis, some statistical measures the mean, the standard deviation, and how often each category appears were adopted to summarize the data and get to know the main changes in the Lean implementation and the productivity indicators. Besides, correlation investigation was performed to identify the degree and the direction of relations between the Lean tools and the productivity performance.

Regression analyses were run to verify the hypotheses and find out the conception of the independent variables on

the dependent variable. This way we got to know how much Lean practices such as 5S, Kaizen, TPM, VSM, and JIT affect productivity measures like efficiency, cycle time reduction, and machine utilization. Statistical tools including SPSS and Microsoft Excel were used for carrying out the analysis, which was consistent and accurate.

In conjunction with other data, qualitative findings derived through the interview process were studied to determine the shared themes, as well as the difficulties and obstacles encountered by MSMEs during Lean implementation. Such ideas were used together with quantitative results and thus gave a more thorough explanation of real-time operation.

The same are laid out in tables and charts and graphs that have clear writing and are visually explained by reference to the content of their sections. By focusing on the discovery of patterns, trends, and even statistically significant associations, the analysis makes sure that the results are relevant to the research goals and that they either concur with or negate the hypotheses that have been set up.

DESCRIPTIVE STATISTICS (Mean & Standard Deviation) Table 1: Descriptive Statistics of Lean Tools

Lean Tool	Mean	Std. Deviation	Interpretation
5S	3.85	0.82	High adoption level
Kaizen	3.72	0.88	Moderately high adoption
TPM	3.45	0.95	Moderate adoption
VSM	3.30	1.02	Moderate adoption
JIT	3.10	1.10	Relatively lower adoption

Interpretation

The correlation analysis reveals that all Lean tools are positively related to productivity performance. Out of which 5S and Kaizen represent the most positive correlations, highlighting that these two Lean tools are the main driving forces to enhance operating performance and efficiency. Given that all p-values are lower than 0.05, the associations are statistically significant. Thus, the null hypothesis (H_{02}) can be rejected, and it is demonstrated that Lean tools do affect productivity.

CORRELATION ANALYSIS

Table 2: Correlation between Lean Tools and Productivity

Variable	Productivity Performance (r)	p-value	Interpretation
5S	0.62	0.001	Strong positive correlation
Kaizen	0.58	0.003	Strong positive correlation
TPM	0.51	0.010	Moderate positive correlation
VSM	0.46	0.020	Moderate positive correlation
JIT	0.40	0.035	Moderate positive correlation

Interpretation

Results of correlation analysis reveal that all Lean tools show a positive correlation with productivity performance. Especially, 5S and Kaizen stand out with the highest correlations suggesting that these tools play a major role in enhancing efficiency and operational performance. As all the p-values are less than 0.05, these results are statistically significant. Thus, it is supported to reject the null hypothesis (H_{02}) and to say that Lean tools do have an impact on productivity.

REGRESSION ANALYSIS

Table 3: Regression Results (Lean Tools → Productivity)

Variable	Beta Coefficient (β)	t-value	p-value	Interpretation
5S	0.35	3.80	0.000	Significant positive impact
Kaizen	0.30	3.25	0.002	Significant positive impact
TPM	0.22	2.45	0.016	Moderate impact
VSM	0.18	2.10	0.038	Moderate impact
JIT	0.15	1.95	0.045	Lower but significant impact

Model Summary:

R	R^2	Adjusted R^2	F-value	Significance
0.72	0.52	0.49	18.65	0.000

Interpretation

The results of the regression demonstrate that Lean tools as a whole account for 52% of the differences in productivity performance (R^2=0.52), which is an excellent model. Out of all variables, 5S has the greatest effect, then comes Kaizen, thus these two interventions play a very important role in enhancing the productivity of MSMEs. Besides, all the variables have a p-value of less than 0.05, so we can say that they all really influence productivity.

The significance of the F-value ($p < 0.05$) indicates that the whole regression model is statistically acceptable. So, the null hypothesis (H_{02}) is not supported, and the alternative hypothesis (H_{12}) is supported instead.

Barriers to Lean Manufacturing Implementation

Barrier	Frequency (n)	% of Organizations	Mean Score	Interpretation
Lack of Skilled Manpower	11	55.0%	2.75	Major barrier
Resistance to Change	8	40.0%	2.00	Significant barrier
Lack of Training	7	35.0%	1.75	Moderate barrier
Time Constraints	6	30.0%	1.50	Moderate barrier
Financial Constraints	4	20.0%	1.00	Less significant barrier
Lack of Top Management Commitment	4	20.0%	1.00	Less significant barrier

Interpretation

The table above shows the main problems of MSMEs in adopting Lean Manufacturing. According to the data, 55% of organisations pointed out the shortage of skilled manpower as the biggest problem, and this was also the one with the highest average score of 2.75. It means that, mainly, the lack of technical know- how is holding back the implementation of Lean the most.

Resistance to change is yet another important problem; it affects 40% of organisations, which means difficulties in accommodating new processes and practices. Besides this, lack of proper training and time shortage are still minor issues, indicated by the need for training sessions and a time management strategy.

Financial problems and lack of top management support are considered less significant barriers in this research. In summary, the findings suggest that human and organisational issues matter more than financial aspects when it comes to Lean implementation.

VI. RESULTS AND DISCUSSION

The results of the descriptive statistics show that Lean Manufacturing is still at a moderate level of implementation in MSMEs in Gujarat. Although 5S and Kaizen registrations were high, suggesting that these MSMEs are focused on implementing the basic Lean methods that hardly need any changes. On the contrary, Just-in-Time (JIT) and Value Stream Mapping (VSM) that represent advanced Lean methods have much less exposure, pointing to a small number of MSMEs that have after Lean quite integrated comprehensive systems.

Results from correlation analysis reveal that Lean tools and productivity performance are positively and significantly correlated. Correlations of the strongest positive signals still belong to 5S and Kaizen tools, which illustrate the ability of the two to directly enable better operations, less waste, and smoother workflow. All relations being significant ($p < 0.05$), thus, null hypothesis (H_{02}) is rejected and alternative hypothesis (H_{12}) is accepted. Hence, it is clear that Lean tools do significantly affect productivity in MSMEs.

Regression results additionally confirm that Lean tools have, as a group, a very notable role and impact on the productivity of MSMEs. In fact, the regression explains the variation of the dependent variable very well. As far as impact is concerned, out of all tools 5S is recognized as the most powerful one, followed by Kaizen, which implies that tidiness of the workplace and continuous improvement are indeed major driving forces for productivity growth. Given the fact that the whole model is statistically significant further strengthens the trustworthiness of the findings which cannot be done without revisiting hypothesis (H_{12}).

Regarding the level of Lean adoption, the results indicate that MSMEs are engaged with Lean practices to a significant extent in statistical terms. However, the level of adoption varies from firm to firm. This situation encouraged the rejection of the null hypothesis (H_{01}) to the acceptance of alternative hypothesis (H_{11}). In other words, Lean Manufacturing is being implemented although the firms are at different stages.

One of the major findings of the barrier analysis is that lack of skilled human resources is the biggest problem in implementing Lean, with resistance to change and lack of training coming second, third respectively. Moreover, time limitation may be the main obstacle of many organizations. Unexpectedly, this study shows that the financial condition and the level of top management's commitment to the decision are not very influential factors. These results show that human resource and behavioral aspects have a greater impact than the financial ones in blocking the implementation of Lean. So, the null hypothesis (H_{03}) has been rejected and the alternative hypothesis (H_{13}) was accepted, which confirms that MSMEs do encounter major barriers in implementing Lean Manufacturing practices.

This paper's results echo earlier research which states that MSMEs often resort to the adoption of basic Lean tools first as they require less expertise, training, and organizational readiness while advanced practices need more thereof.

Besides, the paper's findings prove the successful implementation of Lean Manufacturing as a path to achievement of higher levels of productivity and operational performance which is a core principle of the Lean methodology.

In sum, research reveals that Lean Manufacturing bring about changes in productivity to a large extent and positively, however, the actual level of achievement is limited by the real world difficulties, especially those which are associated only with the capacity, training, and readiness of the organization. This set of data supply theoretical thoughts as they verify the Lean philosophy and hint practical directions by revealing the aspects to which the MSMEs require assistance in order to increase Lean implementation.

VII. CONCLUSION

The primary objective of this study was to find out how deeply Lean Manufacturing has been adopted by MSMEs in Gujarat, what has been its effect on the productivity performance, and what are the main barriers that have been preventing its implementation. Results demonstrate that while Lean practices are being introduced one after another by MSMEs, the extent of their implementation is still moderate and differ from one organization to another.

The results from the study solidly point to the fact that Lean Manufacturing significantly and positively contributes to productivity performance. Simple methods like 5S and Kaizen largely contribute to boosting efficiency, lowering waste, and making the processes more effective. Due to their simplicity, these methods are more commonly used. On the other hand, advanced techniques such as Just-in-Time and Value Stream Mapping are the least used ones.

The research, however, combined with the above, throws light on some other major barriers that lean the implementation of lean practices in an irregular pace. Among these lack of skilled labor, reluctance to change and unavailability of adequate training have been identified as the most important issues. It is apparent that financial factor is not the only or even the most significant factor as human and organizational issues stand out in this respect as well.

Overall, this research work reveals that despite Lean Manufacturing being a great source of productivity and competitiveness enhancement, the environment within the organization, capability of the workforce, and determination of the management play a very big role in the success. A gradual, planned and well- articulated approach, supplemented with training and awareness programs, can really help the MSMEs to overcome the challenges and gain the improvements that can be sustained.

On the one hand from a scholarly perspective, on the other from the viewpoint of the practitioners, this investigation reaches the agreement that the use of Lean methods is definitely a drivers for the enhancement of productivity; at the same time it offers quite a number of suggestions which can be directly used for the purpose of improved implementation in the real industrial environment. It points out that without the effort of making it better from time to time, without strengthening the abilities, and without the support of the management it may not be possible to obtain the full benefits of the Lean Manufacturing.

To sum up, enhancing Lean adoption in MSMEs probably can be a major factor in operational excellence, cost efficiency, and long-term industrial progress, which will allow the organizations to stay competitive in the ever-changing business world.

The true success of Lean Manufacturing in MSMEs lies not only in adopting its tools, but in developing a culture of continuous improvement that drives sustainable performance and long-term growth.

VIII. LIMITATIONS

While the study offers important insights into how Lean Manufacturing is adopted and its effects on productivity in MSMEs, it still has some limitations that warrant mention.

One of the limitations is the size and geographical spread of the sample, which consisted only of a small number of MSMEs from few GIDC industrial clusters in Gujarat. So, the results might not represent all MSMEs from different

regions or sectors.

The data used in the study are mostly based on self-assessments via questionnaires and interviews that might be subject to bias. Participants may have given responses that they considered more socially acceptable or might have failed to give an accurate picture of their organizations' practices.

Moreover, this research is based on a cross-sectional design, and only meio-time data were captured. Therefore, it ignores variations in Lean implementation and productivity levels over time, which a longitudinal study could highlight.

Besides, the research only deals with a few Lean instruments (5S, Kaizen, TPM, VSM, and JIT) as well as particular productivity metrics. Organizational culture, technological innovations, or external market forces, for example, which also significantly impact the productivity of organizations, have not gone through a thorough study.

Also, limitations in time and resources might have restricted the extent to which data collection and analysis could be carried out. Other organizations might have been reluctant to share their detailed operational data, thus limiting the comprehensiveness of the study.

IX. REFERENCES

- Womack, J.P. and Jones, D.T., 2003. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. New York: Free Press.
- Ohno, T., 1988. *Toyota Production System: Beyond Large-Scale Production*. Portland: Productivity Press.
- Shah, R. and Ward, P.T., 2003. Lean manufacturing: Context, practice bundles, and performance. *Journal of Operations Management*, 21(2), pp.129–149.
- Liker, J.K., 2004. *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*. New York: McGraw-Hill.
- Kumar, R. and Kumar, V., 2014. Lean manufacturing in Indian industries: A review. *International Journal of Engineering Research and Applications*, 4(3), pp.23–28.
- Singh, B., Garg, S.K. and Sharma, S.K., 2010. Development of index for measuring leanness: Study of Indian small scale industries. *International Journal of Industrial Engineering*, 17(1), pp.46–58.
- Gupta, S. and Jain, S.K., 2013. A literature review of Lean Manufacturing. *International Journal of Management Science and Engineering Management*, 8(4), pp.241–249.
- Government of India, 2022. *Annual Report on MSMEs*. Ministry of Micro, Small and Medium Enterprises. Available at: https://msme.gov.in (Accessed: 31 March 2026).
- Melton, T., 2005. The benefits of Lean Manufacturing: What Lean thinking has to offer the process industries. *Chemical Engineering Research and Design*, 83(6), pp.662–673.
- Panwar, A., Jain, R. and Rathore, A.P.S., 2015. Lean implementation in Indian process industries – Some empirical evidence. *Journal of Manufacturing Technology Management*, 26(1), pp.131–160.