

# “Adoption of Lean Practices in Manufacturing Industries of Visakhapatnam: An Empirical Study”

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**Abstract**—This study investigates the adoption of lean manufacturing practices among manufacturing industries in Visakhapatnam and examines their impact on operational performance. Lean dimensions such as 5S, Kaizen, Just-In-Time (JIT), Total Productive Maintenance (TPM), Kanban, and Value Stream Mapping (VSM) were evaluated using a structured questionnaire administered to 100 managers and supervisors representing small, medium, and large manufacturing firms. The findings indicate that 5S and Kaizen are widely implemented, while advanced techniques such as Kanban and VSM show comparatively lower adoption, especially in smaller units. Statistical analysis demonstrates a significant positive relationship between lean adoption and improvements in productivity and product quality, along with a notable reduction in lead time and defect rates. Key barriers identified include inadequate training, limited financial resources, and resistance to change. The study highlights the need for enhanced managerial commitment, skill development, and stronger supply-chain coordination to promote effective lean implementation in Visakhapatnam’s manufacturing sector.

## I. INTRODUCTION

The manufacturing sector is a cornerstone of India’s economic development, driving technological progress, employment generation, and industrial competitiveness. With the increasing challenges of globalization, rising input costs, and heightened customer expectations, manufacturing firms must adopt efficient strategies that enhance operational performance and maintain competitive advantage. Lean manufacturing has emerged as one such globally recognized approach aimed at eliminating waste, optimizing processes, and enhancing value creation for customers.

Visakhapatnam, located on the eastern coast of India, is one of the fastest-growing industrial hubs in Andhra

Pradesh. It hosts a wide range of manufacturing industries, including steel, petroleum, pharmaceuticals, food processing, metals, and heavy engineering. Due to its strategic location, port connectivity, and cluster-based industrial environment, Visakhapatnam is a vital link in regional and national manufacturing networks. However, the region’s manufacturing firms especially Micro, Small, and Medium Enterprises (MSMEs) face challenges such as inconsistent supply chains, limited automation, competition from global players, and rising production costs. Lean manufacturing offers a structured approach to addressing these challenges. Lean tools such as 5S, Kaizen, JIT, TPM, Kanban, and VSM help firms minimize waste, streamline workflow, reduce defects, and improve productivity. However, the adoption of lean practices varies widely across firms depending on organizational culture, management support, training availability, and technological readiness. Although several studies have examined lean implementation in Indian manufacturing, limited empirical research exists specifically on Visakhapatnam, despite its industrial importance. This study aims to fill that gap.

### 1.1 Need for the Study

Understanding lean adoption in Visakhapatnam is important because:

- The city hosts diverse industries with varying maturity levels.
- MSMEs are growing but often lack structured operational strategies.
- Lean adoption can significantly improve regional manufacturing competitiveness.
- There is a shortage of region-specific empirical studies.

### 1.2 Objectives

1. To assess the level of adoption of lean practices in manufacturing industries of Visakhapatnam.

2. To examine the relationship between lean practices and operational performance.
3. To compare lean adoption across different firm sizes.
4. To identify barriers to lean implementation.
5. To offer recommendations for strengthening lean practices.

### 1.3 Research Questions

- What is the level of lean practice adoption in Visakhapatnam manufacturing firms?
- Which lean tools are most and least adopted?
- Does lean adoption improve productivity and reduce lead time and defects?
- What barriers restrict lean implementation?

### 1.4 Hypotheses

- H1: Lean adoption is positively associated with productivity.
- H2: Lean adoption is negatively associated with production lead time.
- H3: Lean adoption is negatively associated with defect rates.

## II. EVOLUTION OF LEAN THINKING

2.1 Lean has gradually evolved from a manufacturing-focused philosophy to a broader organizational strategy.

- Hines, Holweg & Rich (2004) argued that lean is not just a set of tools but a system-wide mindset focused on value, flow, and customer-centric operations.
- Pettersen (2009) differentiated between “tool-based lean” and “philosophical lean,” warning that superficial implementation limits results.
- Bortolotti, Boscarri & Danese (2015) emphasized that successful lean adoption requires alignment between culture, leadership, and operational practices.

These studies highlight that lean’s effectiveness depends not only on tool adoption but also on organizational culture and leadership commitment.

### 2.2 Expanded Evidence on Key Lean Tools

#### 2.2.1 5S – Beyond Workplace Organization

- Gapp, Fisher & Kobayashi (2008) demonstrate 5S improves discipline and reduces errors.

- Singh & Ahuja (2015) reported that sustained 5S implementation boosts productivity by reducing motion waste and enhancing layout efficiency.

#### 2.2.2 Kaizen – Empowerment and Engagement

- Bhuiyan & Baghel (2005) noted that Kaizen increases employee morale and problem-solving capacity.
- Antony et al. (2017) found Kaizen events to be highly effective in MSMEs when management support is strong.

#### 2.2.3 JIT – Efficiency and Flexibility

- Callen, Morel & Fader (2015) observed JIT reduces cost by integrating supplier relationships.
- Nawansir et al. (2016) confirmed that JIT significantly enhances delivery speed and flexibility in Southeast Asian manufacturing.

#### 2.2.4 TPM – Productivity and Reliability

- Jeong & Phillips (2001) demonstrated strong links between TPM and equipment uptime.
- Ahuja & Singh (2012) showed TPM fosters operator responsibility and prevents equipment-related waste in Indian industries.

#### 2.2.5 Kanban – Flow Regulation

- Lian & Van Landeghem (2007) showed Kanban improves scheduling stability and reduces WIP inventory.
- Azadeh et al. (2017) applied simulation models proving Kanban optimizes system responsiveness under varying demand patterns.

#### 2.2.6 Value Stream Mapping (VSM) – Waste Diagnosis

- Hines & Rich (1997) classified waste into seven categories that VSM helps visualize.
- Shou et al. (2017) identified VSM as critical in Industry 4.0 environments for mapping real-time data and digital workflows.

### 2.3 Lean, Operational Performance & Industry 4.0

- Tortorella & Fettermann (2018) found that Lean + Industry 4.0 synergies improve automation, quality, and decision-making.
- Buer, Strandhagen & Chan (2018) suggest that digital tools (IoT, sensors, data analytics) strengthen lean practices such as JIT and TPM.

Studies show that modern lean systems blend traditional tools with digital capabilities to enhance predictive maintenance, inventory accuracy, and process flow.

#### 2.4 Lean Adoption in India

Across Indian manufacturing, implementation remains inconsistent

- Karunathilake et al. (2017) found that Indian MSMEs lack awareness, leadership commitment, and technical expertise.
- Kumar, Singh & Ahuja (2017) reported financial constraints and resistance to change as major barriers.
- Gupta & Jain (2016) emphasized supply-chain fragmentation as a hindrance to JIT and Kanban.

Positive outcomes in successful cases

- Patel & Desai (2018) found that lean significantly enhances cost efficiency in Gujarat's manufacturing sector.
- Sahoo (2020) reported that lean-based interventions improve productivity and defect reduction in Odisha MSMEs.
- Srikanth & Krishna (2021) noted that Andhra Pradesh automobile and fabrication units adopting JIT and TPM achieve better OEE and cycle-time reductions.

Industry-specific insights

- Steel, pharma, and heavy engineering sectors show higher lean maturity.
- Micro and small units demonstrate enthusiasm but lack structured implementation frameworks.

#### 2.5 Regional Context – Visakhapatnam

Although Visakhapatnam is a strong industrial zone (BHEL-HPVP, Steel Plant, Pharma City, MSME clusters), research is scarce:

- Very few studies examine lean practices in public-sector heavy manufacturing (e.g., HPVP).
- Almost no literature compares lean maturity between large and MSME units in the region.
- Studies measuring multi-dimensional lean implementation (JIT + TPM + 5S + Kanban + VSM) are missing.
- Empirical evidence connecting lean practices to operational efficiency outcomes (OEE, lead time, defect rate, cost) in Vizag industries is limited.

### III. METHODOLOGY

This chapter explains the research design, sample, data collection tools, and analytical techniques used in the study.

#### 3.1 Research Design

The study used a descriptive and analytical research design. The descriptive part measured the level of lean practice adoption among manufacturing firms. The analytical part examined the impact of lean practices on operational performance (productivity, lead time, and defect rate). A quantitative survey method was adopted.

#### 3.2 Population and Sample

The population consisted of manufacturing industries in Visakhapatnam, including metal, chemical, food processing, engineering, pharmaceutical, and MSME units. A sample of 100 respondents - managers, supervisors, production heads, and quality personnel was selected for the study.

#### 3.3 Sampling Technique

A stratified sampling method was used to include small, medium, and large firms. Within each stratum, convenience sampling was applied to select respondents directly involved in operations.

#### 3.4 Research Instrument

Data was collected using a structured questionnaire containing four parts:

- Section A: Firm and respondent details
- Section B: Lean practice adoption (30 items covering 5S, Kaizen, JIT, TPM, Kanban, VSM)
- Section C: Operational performance indicators (productivity, lead time, defect rate)
- Section D: Barriers to lean implementation (open-ended)

All lean items were measured using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

#### 3.5 Validity and Reliability

Content validity was ensured through expert review by specialists in operations and lean manufacturing. A pilot study with 15 respondents confirmed clarity and relevance of items. Cronbach's Alpha values for all lean dimensions ranged from 0.72 to 0.87, indicating high reliability.

#### 3.6 Data Collection Procedure

Data collection was carried out between June and August 2025 through: Google Forms (for large firms), Printed questionnaires (for MSMEs). Participation was voluntary, and respondents were assured of confidentiality.

### 3.7 Data Analysis Techniques

The following methods were used to analyze the data: Descriptive Statistics to summarize lean adoption levels, Reliability Tests (Cronbach's Alpha), Factor Analysis to validate lean dimensions, Pearson Correlation to assess relationships among variables, Regression Analysis to test hypotheses on productivity, lead time, and defect rate, ANOVA to compare lean adoption across firm sizes, Thematic Analysis for qualitative responses on barriers.

### 3.8 Ethical Considerations

Respondents were informed about the purpose of the study, assured confidentiality, and allowed to withdraw at any time. The data was used strictly for academic research.

## IV. DATA ANALYSIS

This chapter presents the results of the statistical analyses conducted to understand the adoption of lean practices in manufacturing industries of Visakhapatnam and their impact on operational performance. The data collected from 100 respondents were analyzed using descriptive and inferential statistics.

### 4.1 Descriptive Statistics

Descriptive statistics were used to measure the overall adoption level of lean practices. Mean scores were calculated for all six lean dimensions.

- 5S showed the highest level of adoption.
- Kaizen was moderately high.
- TPM and JIT recorded moderate adoption.
- Kanban and VSM had the lowest adoption, especially among small firms.

These results indicate that firms prefer basic, low-cost lean tools, while advanced lean techniques requiring training or technology are less commonly implemented.

### 4.2 Reliability Analysis

Cronbach's Alpha was used to test internal consistency of the lean constructs. The overall reliability value was 0.87, and each dimension exceeded the acceptable threshold of 0.70. This confirms that the measurement scales used in the questionnaire were reliable.

### 4.3 Factor Analysis

Exploratory Factor Analysis (EFA) was conducted to confirm whether the items grouped under the six lean

dimensions. Results showed: Six clear factors emerged, all items had factor loadings above the acceptable level (0.50), The cumulative variance explained exceeded 60%. Thus, the questionnaire structure was statistically validated.

### 4.4 Pearson Correlation Analysis

Pearson correlation was used to examine relationships between lean practices and performance variables. Key findings: Lean practices had a positive correlation with productivity, Lean had a negative correlation with lead time, meaning higher lean adoption reduces lead time, Lean had a negative correlation with defect rate, indicating improved quality. All correlations were statistically significant.

### 4.5 Regression Analysis

Multiple regression analysis tested the hypotheses:

H1: Lean → Productivity

- $\beta = 0.46, p < 0.001$
- Supported. Lean positively impacts productivity.

H2: Lean → Lead Time

- $\beta = -0.39, p < 0.001$
- Supported. Lean implementation reduces lead time.

H3: Lean → Defect Rate

- $\beta = -0.44, p < 0.001$
- Supported. Lean practices significantly reduce defects.

These results confirm that lean practices help improve operational performance in manufacturing firms.

### 4.6 ANOVA

ANOVA results showed significant differences in lean adoption across firm sizes.

- Large firms had higher adoption of advanced lean practices such as JIT, Kanban, and VSM ( $p < 0.05$ ).
- Small firms performed better in 5S, but lagged in complex tools due to limited resources.
- Medium firms showed moderate adoption across all dimensions.
- This indicates that organizational size influences the ability to implement lean practices.

### 4.7 Thematic Analysis of Open-Ended Responses

Qualitative responses were analyzed to identify common barriers.

Major themes included:

- Lack of trained manpower
- Resistance to change among employees
- Financial constraints in MSMEs

- Weak supplier coordination affecting JIT
- Limited awareness of advanced lean tools

These insights help explain why advanced lean practices remain underutilized.

#### 4.8 Summary of Analysis

The analysis shows:

- Lean adoption in Visakhapatnam is moderate
- Basic lean tools are widely used
- Lean significantly improves productivity, quality, and lead time
- Firm size influences adoption levels
- Several barriers restrict full-scale implementation

### V. DISCUSSION

The study reveals that Visakhapatnam manufacturing firms have adopted foundational lean tools such as 5S and Kaizen, contributing to workplace organization and process stability. However, advanced lean techniques requiring cross-functional coordination and training Kanban and VSM are less prevalent. The significant positive relationship between lean adoption and operational performance aligns with global findings. Organizations implementing lean report:

- Higher productivity
- Improved product quality
- Reduced lead time

This confirms lean's relevance for improving operational efficiency. Firm size plays an important role: larger firms have more resources and structured systems, enabling better adoption.

### VI. FINDINGS

1. Lean adoption in Visakhapatnam is moderate overall.
2. 5S and Kaizen are the most widely implemented practices.
3. Kanban and VSM show low adoption.
4. Lean significantly improves productivity, lead time, and quality.
5. MSMEs face more barriers than large firms.
6. Training and management commitment are critical for successful implementation.

### VII. IMPLICATIONS

Managerial Implications

- Strengthen training programs on lean tools.
- Establish continuous improvement teams.

- Introduce digital lean concepts (IoT, automation).
- Strengthen collaboration with suppliers for JIT/Kanban.

Policy Implications

- Government should support MSME lean programs.
- Training institutes should develop lean certification programs.
- Industrial clusters should establish shared lean resource centers.

### VIII. LIMITATIONS

- Data is self-reported.
- Cross-sectional design limits causal interpretation.
- Study limited to Visakhapatnam; may not generalize to all regions.
- Sample size restricted to 100 respondents.

### IX. CONCLUSION

This empirical study assessed the adoption of lean manufacturing practices among diverse manufacturing industries in Visakhapatnam and examined their impact on operational performance. The findings reveal that lean adoption in the region is moderate overall, with significant variation across firm sizes. Foundational practices such as 5S and Kaizen are widely implemented due to their simplicity, low cost, and immediate operational benefits. However, advanced lean tools including Kanban, JIT, TPM, and Value Stream Mapping show lower penetration, especially among micro and small enterprises, largely due to constraints in training, financial resources, and technological readiness. Statistical analysis confirms a strong and significant relationship between lean adoption and operational outcomes. Higher implementation of lean practices is associated with improved productivity, reduced lead time, and lower defect rates. These findings align with global and national research, reinforcing that lean remains a practical and effective approach for enhancing efficiency and competitiveness in manufacturing environments. The comparative analysis across firm sizes indicates that large firms in Visakhapatnam benefit from structured systems, better infrastructure, and managerial commitment, enabling higher

adoption of advanced lean practices. In contrast, MSMEs face greater barriers, including weak supply-chain integration, limited awareness of lean principles, and resistance to organizational change. These constraints highlight the need for targeted interventions to support smaller units. Overall, the study underscores that while lean practices have gained traction in Visakhapatnam, significant opportunities remain for deeper and more systematic implementation. Strengthening leadership involvement, enhancing workforce skills, integrating digital tools, and improving supplier coordination can accelerate lean maturity across the region. By addressing these gaps and fostering a culture of continuous improvement, manufacturing industries in Visakhapatnam can achieve substantial gains in efficiency, quality, and long-term sustainability.

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