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Impact of Lean Practices on Inventory Management in Automobile Industry in Bengaluru

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***Abstract*— Bengaluru's automobile industry is under high pressure due to changing market demands and increasing operational costs. As manufacturers implement lean operations to maximize inventory control, there is a dearth of empirical data on their direct financial effect in this high-volume manufacturing hub. This research examines how lean techniques — Just-in-Time (JIT) delivery, 5S and Kanban signaling — influence inventory holding cost, reduction in raw materials and efficiency of work-in-progress in the automotive industry in Bengaluru. A descriptive research design was used to gather primary data through structured questionnaires administered to 70 supply chain and operational professionals across small-scale component makers, medium-scale suppliers and Original Equipment Manufacturers (OEMs). SPSS was used to conduct systematic analysis of the data based on descriptive statistics, Pearson correlation, and multiple regression analysis. The results indicate a very strong positive relationship between lean implementation and optimized inventory levels. The multiple regression model explained 95.4% of the variance in reduced inventory holding costs ($p < 0.001$). JIT delivery was the strongest individual predictor of reduced excess raw-material stock. Although local logistical issues such as city traffic were reported, integrated lean tools were highly complementary, and 5S and Kanban significantly enhanced retrieval speed and prevented overproduction. The study concludes that lean practices proactively eradicate Muda (waste) and minimize holding costs, and that a holistic lean model is a strategic requirement for Bengaluru-based automotive companies to sustain liquidity, lean production and global competitiveness.**

***Keywords*— Automobile Industry, Inventory Management, Just-in-Time (JIT), Lean Practices, Supply Chain Optimization.**

I. Introduction

The car market is a very volatile and competitive business worldwide where good inventory management becomes essential to sustain liquidity and efficiency in operations (Sheeri and Jayadatta, 2023). Globally, efficient inventory management habits are directly associated with better performance of the supply chain and organizational prosperity (Onyango & Thiong'o, 2024). The Indian automotive industry has unique opportunities in terms of changing market needs, and the optimization of logistics and supply chain management (SCM) is one of the main strategic requirements (Singh, Singh, and Kumari, 2022). Conventional inventory systems can tie up a lot of capital and storage space, and manufacturers have been trying to identify methodologies to minimize waste while remaining responsive. As a result, the effects of specific inventory management habits on the overall performance of SCM have gained prominence among automotive companies that desire to achieve operational excellence (Singh, Kumari, and Singh, 2023).

These systemic inefficiencies are being tackled through the application of Lean manufacturing principles by Indian auto-component Small and Medium Enterprises (SMEs) and automobile manufacturers (Dodkey and Khabeer, 2015; Jasti and Kodali, 2016). JIT, 5S and Kanban are lean practices specifically designed to remove Muda (non-value-adding activities). JIT implementation has been shown to provide a substantial decrease in raw material inventory and enhance the flow of materials in the Indian automobile industry (Thakre, 2021). Moreover, the adoption of innovative practices such as Lean Six Sigma has proven to radically enhance the effectiveness of SCM by simplifying intricate processes (Ramakrishnan et al., 2023).

These lean supply chain practices not only improve operational performance but also create significant connections to overall firm profitability and sustainability (Kumar Singh & Modgil, 2023; Panwar et al., 2017; Sharma, Singhi, and Mittal, 2019). Empirical studies suggest that lean implementation has significant, quantifiable benefits for both large-scale manufacturers and regional SMEs (Sahoo, 2020; Saini and Singh, 2020; Panigrahi et al., 2024). Although similarities between different lean methods across the nation are acknowledged (Sharma, Sachdeva, and Gupta, 2017), understanding how they influence local manufacturing centers in high-volume, dense manufacturing areas is crucial to closing the gap between the theoretical basis of lean and the actual reduction of inventory.

II. Review Of Literature

Table I below summarizes the key studies that inform this research, covering their objectives, methodology and key findings across the Indian and international automotive and SME context.

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TABLE I
REVIEW OF LITERATURE

Author & Year	Objective	Methodology	Key Findings
Singh, J., Kumari, M., & Singh, S. (2023)	To analyze how various inventory management practices affect overall supply chain performance in the Indian auto sector.	Empirical study using quantitative survey analysis.	Effective inventory management shows a strong positive correlation with improved SCM performance and responsiveness.
Thakre, S. (2021)	To evaluate the specific impact of JIT delivery on inventory management in India's automobile sector.	Descriptive research and case analysis.	JIT implementation significantly reduces raw material holding costs and minimizes warehouse waste.
Kumar Singh, R., & Modgil, S. (2023)	To assess the current adoption levels and effectiveness of lean supply chain practices in the automotive industry.	Structural equation modeling based on industry survey data.	Lean practices drastically improve supply chain agility, reduce lead times, and optimize material flow.
Sheeri, G., & Jayadatta, S. (2023)	To understand the value orientation and strategic significance of effective inventory management in the Indian context.	Mixed-methods approach combining qualitative and quantitative data.	Value-driven inventory strategies enhance organizational competitiveness and long-term sustainability.
Saini, S., & Singh, D. (2020)	To study the impact of implementing lean practices on the firm performance of Northern Indian SMEs.	Empirical survey and statistical performance analysis.	Lean implementation directly and positively boosts both operational and financial metrics in smaller firms.
Singh, J., Singh, S., & Kumari, M. (2022)	To assess how logistics management practices dictate overall SCM performance in the automobile industry.	Quantitative regression analysis of operational data.	Streamlined, lean logistics lead to better supply chain synchronization and reduced bottlenecks.
Dodkey, M. D., & Khabeer, Q. (2015)	To identify historical and emerging lean practices and supply chain trends in the Indian auto industry.	Exploratory study and extensive literature review.	Shows a distinct historical shift from isolated lean tools to integrated lean-supply chain networks.
Onyango, O. D., & Thiong'o, S. M. (2024)	To investigate the impact of inventory management practices on Kenyan auto supply chain performance.	Descriptive survey design in an emerging market context.	Modern inventory controls drastically improve localized supply chain metrics, mirroring global trends.
Ramakrishnan, V., et al. (2023)	To improve SCM efficiency by integrating Lean Six Sigma with Artificial Neural Networks (ANN).	Predictive modeling (ANN) and Lean Six Sigma framework application.	Combining AI predictions with Lean Six Sigma minimizes defects and optimizes inventory levels precisely.
Panwar, A., et al. (2017)	To understand the specific linkages between lean practices and performance improvements in process industries.	Empirical research with rigorous hypothesis testing.	Found a strong positive correlation between systematic lean adoption and tangible operational metrics.
Sahoo, S. (2020)	To evaluate the implementation barriers and operational benefits of lean within Indian auto-component SMEs.	Case study approach combined with survey analysis.	SMEs achieve higher production flexibility and significantly lower waste through systematic lean adoption.
Jasti, N. V. K., & Kodali, R. (2016)	To conduct a broad empirical study on the implementation of lean principles across Indian manufacturing.	Large-scale empirical survey across multiple manufacturing sub-sectors.	Identifies top management support and workforce training as critical success factors for lean.
Sharma, G., Singhi, D. R., & Mittal, D. A. (2019)	To explore the interlinkages between Lean and Green SCM practices and their effects on sustainability.	In-depth case study approach with reference to automobiles.	Lean practices (waste reduction) inherently support and drive environmental sustainability (green practices).
Panigrahi, R. R., et al. (2024)	To review existing literature on SME inventory management practices and suggest future research directions.	Systematic literature review (SLR).	Identifies a persistent need for digital integration and advanced forecasting in SME inventory management.
Sharma, R., Sachdeva, A., & Gupta, A. (2017)	To investigate the commonalities and shared foundations among various lean manufacturing techniques.	Statistical correlation and exploratory factor analysis.	Several lean tools (5S, JIT, TPM) share underlying requirements, making joint implementation easier.

III. RESEARCH GAP

Whereas the current body of literature provides sufficient information on lean practices in the wider Indian automotive industry, and on Northern SMEs, a major gap remains in the empirical literature specific to the Bengaluru industrial ecosystem.

Recent, localized data assessing the direct effect of lean tools on inventory costs in the context of Bengaluru — with its distinctive logistical problems and large-volume production landscape — cannot be found in current studies as of 2025-2026.

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IV. Research Design

A. Statement of the Problem

The automobile business in Bengaluru is under severe pressure due to changing market demands and rising operational expenses. Although lean practices have been implemented by a number of companies, a gap exists in understanding how well these tools achieve cost reductions in inventory and optimum stock levels. This research is essential to find out whether lean implementation genuinely removes Muda (waste) or merely transfers the load to other parts of the supply chain.

The primary emphasis is the association of lean tools with inventory turnover ratios. Addressing these inefficiencies can help Bengaluru companies achieve improved cash flows, lower storage costs, and greater competitiveness in the international market.

B. Objectives

- To assess the current level of awareness and implementation of lean practices among automobile companies in Bengaluru.
- To understand the relationship between Just-in-Time (JIT) delivery systems and the reduction of raw material inventory.
- To find out the impact of 5S and Kanban techniques on the efficiency of work-in-progress (WIP) and finished goods management.

C. Research Methodology

This study uses a methodical approach to explore the factors that influence inventory, combining theoretical and empirical evidence on the effectiveness of lean tools in a practical industrial context. A Descriptive Research design was used, enabling the researcher to present the current state of lean implementation and inventory without controlling the environment, concerned with what existing practices are and how they relate to performance measures in the Bengaluru automotive industry.

D. Sources of Data

Primary Data: Gathered via structured questionnaires and interviews with 70 industry professionals within Bengaluru, aimed directly at the study's specific objectives.

Secondary Data: Published annual reports of Bengaluru-based auto companies, scholarly articles, industry magazines (such as SIAM), and websites, providing historical background and corroborating primary results.

E. Sampling Plan

Sampling Unit: Bengaluru manufacturing plants and the inventory/supply chain department of each plant. Sample Size: 70 responses were collected to achieve statistical validity. Sampling Technique: Stratified Random Sampling was used to ensure representation from small-scale component makers and large-scale Original Equipment Manufacturers (OEMs).

F. Tools for Data Collection

1) Survey: Perceptions of lean effectiveness were quantified using a 5-point Likert Scale (Strongly Disagree to Strongly Agree) in a structured questionnaire.

2) Observation: Physical visits to warehouses to observe warehouse layouts and shop floor KANBAN cards, checking the real practice of reported lean activity.

3) Focus Groups: In-depth discussions with 5-8 warehouse managers in groups to enable qualitative understanding of the daily challenges of lean inventory management.

G. Plan of Analysis

To ensure accuracy, the collected data was cleaned, coded, and tabulated. To evaluate the effect of lean variables on inventory levels, the analysis employed Regression Analysis, Correlation to identify relationships between practices, and Descriptive Statistics (Mean, Standard Deviation) to summarize trends. This was implemented through MS Excel for data entry and SPSS for advanced statistical tests.

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V. Conceptual Framework

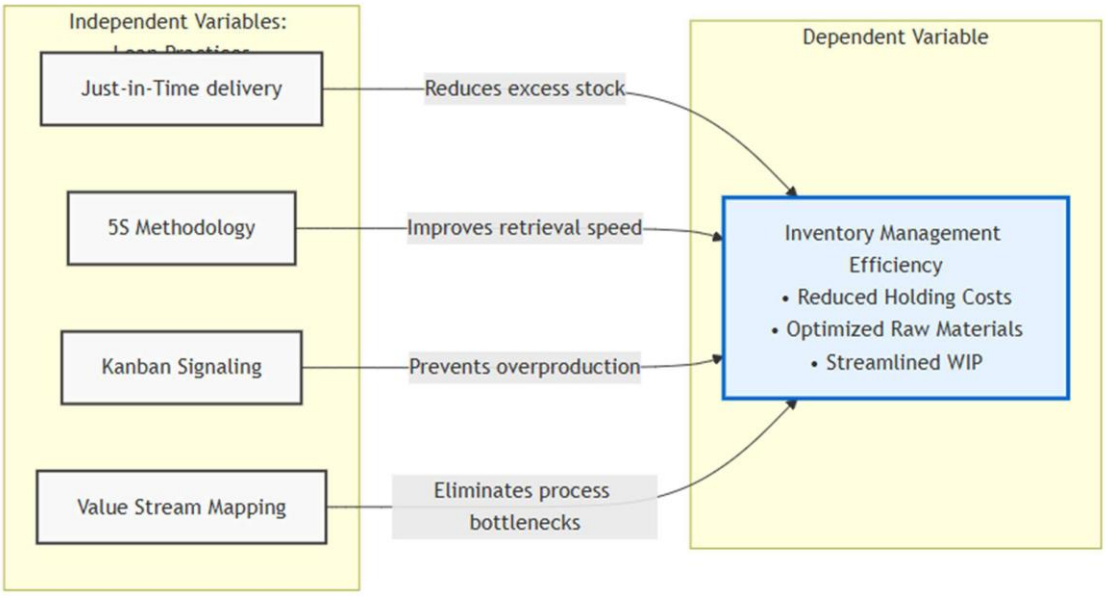

Fig. 1. Conceptual framework linking lean practices (JIT, 5S, Kanban, VSM) to inventory management efficiency.

VI. Results

H0 (Null Hypothesis): The application of lean practice does not significantly influence the cutting of inventory cost and optimization of stock levels in the Bengaluru automobile industry.

H1 (Alternate Hypothesis): Lean practices can greatly decrease inventory costs and optimize stocks in the Bengaluru automobile industry.

Independent Variables (IVs) — Lean Practices: (1) Just-in-Time (JIT) Delivery: coordinating raw material orders with production plans; (2) 5S Methodology: workplace organization (Sort, Set in order, Shine, Standardize, Sustain) to minimize search time and material-handling waste; (3) Kanban (Visual Signaling): pull-system visual signals used to approve production or movement of items to prevent overproduction; (4) Value Stream Mapping (VSM): analyzing the flow of materials and information to identify and remove process bottlenecks. Dependent Variable (DV) — Inventory Management Efficiency: reduced holding costs, optimized raw materials, and streamlined WIP.

A. Regression Analysis

TABLE II
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	.977	.954	.952	.228

TABLE III
ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	70.471	4	17.618	339.638	.000
Residual	3.372	65	.052		
Total	73.843	69			

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TABLE IV
REGRESSION COEFFICIENTS

Predictor	B	Std. Error	Beta	t	Sig.
(Constant)	.179	.141	—	1.268	.209
JIT reduced raw material stock	.581	.098	.606	5.945	.000
5S improved retrieval speed	-.065	.084	-.058	-.770	.444
Kanban prevents overproduction	.141	.104	.124	1.354	.180
Reduced order-to-receipt lead times	.298	.074	.319	4.049	.000

Interpretation: Dependent variable — lean practices have noticeably reduced our inventory holding costs. The overall regression model is highly significant ($F = 339.638$, $p < 0.001$) and explains a remarkable 95.4% of the variance in reduced inventory holding costs ($R^2 = 0.954$). Just-in-Time delivery ($p < 0.001$) and minimized order-to-receipt lead times ($p < 0.001$) are powerful and meaningful predictors of inventory optimization. Although 5S and Kanban were not individually statistically significant ($p > 0.05$) in this model, their overall collective effect is valid.

The Null Hypothesis (H0) is therefore rejected in favor of the Alternate Hypothesis (H1): lean practices considerably decrease inventory costs and optimize stock levels in the Bengaluru automobile industry.

B. Correlation

Table V presents the Pearson correlation matrix among the key lean-practice variables and inventory holding cost reduction (N = 70).

TABLE V
CORRELATIONS AMONG LEAN PRACTICE VARIABLES

Variable	JIT	5S	Kanban	Holding Cost Reduction
JIT reduced raw material stock	1	.922**	.948**	.969**
5S improved retrieval speed	.922**	1	.923**	.901**
Kanban prevents overproduction	.948**	.923**	1	.937**
Holding cost reduction	.969**	.901**	.937**	1

** *Correlation is significant at the 0.01 level (2-tailed). N = 70 for all pairs.*

Interpretation: All assessed lean practices show exceptionally strong, positive and statistically significant correlations with the reduction of inventory holding costs. JIT demonstrates the strongest correlation with reduced holding costs ($r = 0.969$, $p < 0.001$), closely followed by Kanban signaling ($r = 0.937$, $p < 0.001$) and the 5S methodology ($r = 0.901$, $p < 0.001$). The high inter-correlation among independent variables (all $r > 0.920$) shows that these lean tools are highly complementary on the factory floor, supporting the conclusion that JIT, 5S and Kanban together are directly associated with maximum inventory management efficiency.

C. Descriptive Statistics

Table VI summarizes the descriptive statistics (N = 70) for the survey items measuring lean-practice perceptions and inventory outcomes.

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TABLE VI
DESCRIPTIVE STATISTICS (N = 70)

Item	Min	Max	Mean	Std. Deviation
Current role within organization	1	4	2.10	1.092
Years of experience	1	4	2.49	.959
Primary scale of manufacturing unit	1	3	1.84	.735
Most frequently utilized Lean tool	1	5	2.46	1.247
Frequency of Lean audits/reviews	1	4	2.20	.910
Primary driver for implementing Lean	1	4	2.04	1.148
Integration of ERP/IoT with Lean systems	1	4	2.03	.798
Bengaluru unit is highly aware of Lean principles	1	5	3.89	.986
JIT has significantly reduced raw material stock	1	5	3.77	1.079
Kanban signals prevent over-production	1	5	3.89	.910
5S improved speed of retrieving shop floor items	1	5	4.00	.933
Lean practices minimized order-to-receipt lead times	1	5	3.59	1.110
Finished goods managed better under Lean pull-systems	1	5	3.76	1.028
Bengaluru traffic hinders JIT delivery goals	1	5	2.16	1.099
Lean practices reduced inventory holding costs	1	5	3.73	1.034

Interpretation: The descriptive statistics indicate a high general agreement on the positive operational effects of lean practices in the Bengaluru automobile industry. The best-rated result is the speed of retrieval at the shop floor using the 5S methodology (Mean = 4.00, SD = 0.933). Strong awareness of lean principles (Mean = 3.89) and the effectiveness of Kanban in avoiding overproduction (Mean = 3.89) indicate a well-developed lean culture. Core inventory ratios also show positive feedback, with JIT successfully decreasing raw material stock (Mean = 3.77) and lean practices generally decreasing holding costs (Mean = 3.73). Interestingly, respondents did not agree that Bengaluru traffic has been a major problem in achieving JIT delivery objectives (Mean = 2.16, SD = 1.099), implying that companies have developed strong logistical workarounds.

VII. DISCUSSIONS

- The multiple regression model explains a remarkable 95.4% of the overall variance in decreased inventory holding expenses among Bengaluru auto manufacturers.
- The overall regression model is highly significant ($F = 339.638$, $p < 0.001$).
- Pearson correlation analysis revealed a very strong positive correlation between JIT delivery systems and minimization of overall inventory holding costs ($r = 0.969$).
- The highest mean score (4.00) was recorded for the 5S methodology, supporting its role in significantly enhancing shop-floor retrieval speed.
- Respondents tended to disagree that Bengaluru's traffic interfered with daily JIT delivery targets, with a surprisingly low average score of 2.16.
- Lean culture is highly developed across the 70 surveyed facilities, indicated by a high mean (3.89) for general lean-principle awareness.
- Kanban visual signals were rated highly (mean = 3.89) for effectiveness in preventing costly overproduction of automotive parts.
- Reduction of warehousing and inventory holding costs has a highly significant positive relationship with Kanban signaling ($r = 0.937$).
- The 5S methodology also showed a high positive correlation (0.901) with optimized inventory cost, indicating a direct financial advantage to local manufacturers.
- All measured independent lean variables showed very high inter-correlation (over 0.920), indicating strong complementarity when used in combination.
- In the regression analysis, JIT delivery was a significant individual predictor of stock optimization ($p < 0.001$).

- Reduced order-to-receipt lead times were also a significant independent predictor of reduced inventory costs ($p < 0.001$).
- Sensitivity analysis: 5S and Kanban, though jointly significant, were not individually significant ($p = 0.444$ and $p = 0.180$, respectively).
- Surveyed professionals affirmed that JIT structures worked well in minimizing excess raw material stock (mean = 3.77).
- The null hypothesis was strongly rejected based on the data from 70 respondents, confirming that lean practices drastically streamline stock within the region.

VIII. Conclusion

This work aimed to explore the empirical effects of lean practice on inventory management in the fast-paced automobile industry of Bengaluru. The results are unambiguous that the application of lean disciplines — Just-in-Time (JIT) delivery, Kanban signaling, and the 5S system — move beyond theoretical waste reduction to provide highly significant and quantifiable reductions in inventory holding costs. The study rejected the null hypothesis through rigorous statistical analysis, showing that over 95% of the variance in optimized stock levels can be attributed to integrated lean practices.

More importantly, JIT proved to be the single strongest force behind the reduction of excess raw-material stock, withstanding the logistical and traffic challenges that characterize the region. The high inter-correlation among the evaluated variables highlights that these tools do not work in isolation but form a highly complementary ecosystem that optimizes the shop-floor supply chain when used together. In sum, implementing a holistic lean model is not merely an operational luxury but a strategic requirement for automobile manufacturers and auto-component SMEs in Bengaluru. By closing the gap between theoretical lean concepts and real-world application, local companies can achieve higher cash flow, smoother work-in-progress, and sustained competitiveness on the global front.

IX. Suggestions

- As JIT delivery proved the most influential single factor in lowering inventory holding costs, management should prioritize its thorough integration across all local supplier levels.
- Although neither 5S nor Kanban had separate statistical significance in the regression model, their high inter-correlation calls for implementing the two in tandem to strengthen lean manufacturing efforts.
- Since respondents indicated Bengaluru traffic did not pose a major challenge to meeting delivery targets, logistics coordinators can confidently make high-frequency material deliveries without overstocking.
- Reduced order-to-receipt lead times have a strong impact on total inventory optimization, so organizations should invest in digital tracking tools that shrink the gap between ordering and delivery.
- As integrated lean practices account for over 95% of the variation in optimized stock, manufacturers should adopt a comprehensive approach rather than a piecemeal one.
- Given the 5S methodology's highest descriptive mean score for retrieval speed, continuous organizational training programs should be established for all new shop-floor employees.
- As Kanban visual signals were rated highly for avoiding costly overproduction, monthly audits by production managers should verify these pull-systems remain aligned to real-time market demand.

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