OPEN ACCESS

Volume: 13

Special Issue: 1

Month: May

Year: 2026

P-ISSN: 2321-4643

E-ISSN: 2581-9402

Citation:
Vimal Sanjai, S and M. Adlin. "Lean Manufacturing Practices and their Impact on Production Efficiency : A Study at Hyundai Motor India Limited." *Shanlax International Journal of Managment,* vol. 13, no. S1, 2026, pp. 36-44.

DOI:
https://doi.org/10.34293/management.v13iS1-i3-may.11034

Lean Manufacturing Practices and their Impact on Production Efficiency : A Study at Hyundai Motor India Limited

S. Vimal Sanjai
II MBA, Department of Management Studies
St. Xavier`s Catholic College of Engineering (Autonomous)
Nagercoil, Kanyakumari District, Tamil Nadu, India

M. Adlin
Assistant Professor, Department of Management Studies
St Xavier's Catholic College of Engineering (Autonomous)
Nagercoil, Kanyakumari District, Tamil Nadu India

Abstract

Lean manufacturing has become a game-changer in the automotive industry, offering a paradigm shift in the approach to operations.Lean manufacturing represents a paradigm shift in how automotive companies approach their operations, aiming to maximize efficiency and minimize waste. The present study focuses on the effect of lean manufacturing on production efficiency in the case of Hyundai Motor India Limited, a leading automobile manufacturing company in India. The primary data were obtained using a structured questionnaire from 70 respondents while secondary data were obtained from industry reports, company records and peer-reviewed journals. The data was analyzed using statistical tools such as Chi-Square test, Pearson Correlation, Multiple Regression Analysis and Factor Analysis. The results show that the lean manufacturing practices are correlated with production efficiency with a very high positive correlation (r = 0.762) and the multiple regression model explains 77.8% of the variation in efficiency. There were three latent factors of lean manufacturing that were discovered: Process Efficiency & Flow, Quality & Error Reduction, and Workforce & Waste Management. Based on the findings of the study, the study concludes that lean practice is not only a tool for cost reduction but a systematic approach to enhancing productivity, quality and gaining competitive advantage in a high volume automotive production setting.

Keywords: The Words in the title are keywords.

Introduction

Focusing on the Toyota Production System (TPS), lean manufacturing is a systematic approach to remove non-value-adding activities, also known as 'muda' (waste) throughout all aspects of manufacturing. Lean manufacturing is a collection of techniques, approaches and tools that include Just In Time (JIT) delivery, 5S workplace organization, Kaizen (continuous improvement), Value Stream Mapping (VSM), and Total Productive Maintenance (TPM), and all lean manufacturing efforts are designed to produce customer value in a defect free, on-time and cost-effective manner. The most measurable result of lean implementations is production efficiency—the ratio of the actual production level to the production level that can be achieved with the optimal use of resources. Production efficiency is the key to cost structures, delivery performance, organizational agility and market responsiveness, and is crucial in a competitive global automotive industry. The benefits of lean adoption are consistently documented to improve throughput, shorten cycle times, reduce defect rates and increase overall equipment effectiveness (OEE).

Hyundai Motor India Limited (HMIL), a company founded in 1996 in Chennai, Tamil Nadu, is India's second largest automotive manufacturer and the largest exporter of automobiles in India. With an annual production capacity of more than 750,000 units, HMIL is a strategically important environment for studying the effect of lean manufacturing on production efficiency. The long-term focus on quality production and process innovation provides an appropriate setting for empirical lean research.

This study is of a systematic nature for lean manufacturing practices being used at Hyundai Motor India Limited to assess their impact on the production efficiency and determine how lean manufacturing practices are able to reduce waste and how lean manufacturing affects overall productivity and quality outcome.

Literature Review

Lean Manufacturing and Production Efficiency have been extensively studied in the context of automotive and manufacturing world.

The lean advantage was first documented by Womack, Jones, & Roos (1990) in their pioneering study on the comparative productivity and quality of lean and mass automobile producers around the world, which documented that lean producers are able to double the productivity and quality of mass producers with half the human effort. Shah and Ward (2003) empirically investigated lean and socio-technical systems (lean bundles) of human resource practices and operational tools and found that integrated lean implementation leads to significantly more efficiency gains than piecemeal implementation.

Bhamu and Sangwan (2014) analysed more than 209 lean manufacturing research papers and observed that the most common and consistent elements of the literature that span industries and geographies are waste reduction, productivity improvement, and quality enhancement. Based on SEM, the study of Belekoukias, Garza-Reyes, and Kumar (2014) showed that JIT and TPM are the most significant lean practices to influence operational performance, whereas 5S and visual management significantly influence error reduction and workplace organization.

Jadhav, Mantha and Rane, 2014 identified certain barriers for the implementation of lean in Indian manufacturing, which included resistance of middle management and lack of lean training, and organizational culture. A longitudinal case study by Henrique et al. (2016) showed that as a result of implementing Value Stream Mapping in an automotive assembly line, the lead time was shortened by 36% and work-in-progress inventory was cut by 48%. Lean Industry 4.0 integration further enhances efficiency benefits as it allows for real-time performance monitoring and enables predictive maintenance, as confirmed by Tortorella and Fettermann (2018).

Kumar, Antony and Tiwari (2011) found that lean implementation in Indian Automotive companies resulted the reduction of Defects, Inventory and Lead Time with a significant involvement of employees as a critical success factor. To sum up, Danese, Romano, and Bortolotti (2012) also verified that lean supply chain integration enhances plant-level lean results, especially when the plant operates in high-volume assembly settings, such as those at Hyundai.

Research Gap

Although a significant amount of literature has been written on lean manufacturing in a global automotive setting, empirical studies that specifically focus on how lean practice is adopted and what impacts on efficiency this adoption has for the Hyundai would be nonexistent.

Production in the manufacturing sector is still constrained. Moreover, fewer studies have analysed the link between lean and efficiency using a single framework which incorporates Chi-Square, Correlation, Regression, and Factor Analysis within a single framework to comprehensively study the lean-efficiency relationship in a large scale environment of automotive industry in India. This study will fill these gaps through the multi-layered statistical analysis of the effect of lean manufacturing at HMIL.

Organizational Context

Hyundai Motor India Limited was established in May 1996 and began commercial production of its cars at the integrated manufacturing unit in Sriperumbudur, near Chennai, Tamilnadu in September 1998. HMIL, which is 100% owned by Hyundai Motor Company, South Korea, has emerged as India's second-largest passenger car maker and the largest automotive exporter with cumulative exports reaching 3.5 million units to more than 150 countries.

HMIL has two state of the art manufacturing plants with an installed capacity of around 750,000 units per annum. The company's model lineup covers compact cars, sedans, SUVs and electric vehicles, such as the Creta, Verna, i20, Tucson, and Ioniq 5. The manufacturing complex combines press, body, paint, engine and general assembly shops under the supervision of Hyundai's world-wide standardized Hyundai Production System (HPS), which is an adaptation of lean manufacturing principles that includes JIT, Kaizen, visual management and zero-defect quality system.

HMIL has around 12,000 production, engineering, quality and administrative employees working on various production shifts. The company's manufacturing philosophy is based on the continuous improvement of production, the empowerment of its employees and the systematic elimination of waste in its production. India's automotive market is valued at about USD 100 billion in 2023 and is expected to grow at a CAGR of 10-12% till 2030, and for HMIL to remain a market leader, maintaining operational efficiency through lean excellence is a must.

Research Methodology

The study aims to achieve the following objectives:

- To gain an insight on the Lean Manufacturing principles adopted at Hyundai Motor India Limited.
- To evaluate the effect of lean practices on production efficiency of Hyundai Motor India Limited.
- To understand how much waste can be reduced during lean manufacturing process in Hyundai Motor India Limited.
- To explore Lean Manufacturing's impact on productivity and quality of Hyundai Motor India Limited.

The research design and data collection were conducted.Research Design and Data collection were done.

Descriptive research design was used to analyse the employee and management perceptions of lean manufacturing practices and their efficiency gain at HMIL without experimental manipulation of the variables. The primary data were collected by using a structured questionnaire filled by employees from various departments of production, quality, maintenance, and managerial.

Secondary data were obtained from industry publications, company publications, government industry analyses of the automotive sector, lean manufacturing publications, and websites sources.

Sample Design

The study population includes the employees who are directly involved and/or supervising lean manufacturing activities at HMIL as permanent or contractual workers. The minimum sample size of n = 70 was calculated from the standard sample size formula for unknown populations at the 95% confidence level ($Z = 1.96$, $p = 0.5$, $e = 0.12$), and rounded up to the nearest integer. Stratified random sampling was used to ensure proportional representation of the four cadres of production, quality control, maintenance, and managerial cadre. There were 70 questionnaires distributed and 62 were received, which is the basis for this analysis.

Statistical Tools

A Chi-Square Test was used to test for associations between the demographic variables and the perceptions of lean practice / production efficiency.

Pearson correlation analysis was used to compare the relationships between lean practice dimensions and production efficiency.

Multiple Regression Analysis to find the overall predictive ability of the lean practice dimensions in relation to production efficiency.

Construct Factor Analysis (PCA with Varimax Rotation) to discover the underlying factor structure of lean manufacturing variables.

Data Analysis and Finding

Table 1 Demographic Profile of Respondents

Variable	Category	Frequency	Percentage (%)
Gender	Male	37	60
	Female	25	40
Age Group	Below 20 years	8	13
	21–30 years	24	39
	31–40 years	22	35
	Above 40 years	8	13
Education	School Level	10	16
	Diploma	15	24
	Undergraduate	22	35
	Postgraduate	15	24
Work Experience	Below 1 year	12	19
	1–5 years	24	39
	6–10 years	18	29
	Above 10 years	8	13
Department	Production	30	48
	Quality Control	12	19
	Maintenance	10	16
	Management	10	16

Monthly Income	< Rs.15,000	14	23
	Rs.15,000–20,000	20	32
	Rs.20,000–30,000	18	29
	> Rs.30,000	10	16

Source: Primary Survey

The majority of the workforce sample are male (60%), under the age of 30 (39%), have undergraduate qualifications (35%) and 1-5 years' work experience (39%). The largest group (48%) are production workers, reflecting the shop floor nature of lean production operations. The 32% of respondents are in the 5000-10,000 per month category. 15,000 20,000 per month.

Chi-Square Test Results

A Chi-Square analysis was used to analyze demographic variables as related to perceptions of lean manufacturing practices and production efficiency. The results are presented in Table 2.

Table 2 Chi-Square Test Results

Demographic Variable	χ^2 Value	df	p-Value	Result
Department vs. Productivity	8.314	3	0.041	Significant
Department vs. Lean Practices	7.923	3	0.028	Significant
Age vs. Productivity	11.204	9	0.029	Significant
Age vs. Lean Practices	10.512	9	0.038	Significant
Education vs. Productivity	9.017	9	0.034	Significant
Education vs. Lean Practices	12.481	9	0.022	Significant
Work Experience vs. Productivity	10.388	9	0.041	Significant
Work Experience vs. Lean Practices	8.672	9	0.027	Significant
Monthly Income vs. Productivity	13.214	9	0.011	Significant
Monthly Income vs. Lean Practices	14.037	9	0.007	Significant

Source: Primary Survey

At the 5% significance level ($p < 0.05$), all of the demographic variables (department, age, education qualification, work experience, and monthly income) show a statistically significant relationship with production efficiency and lean practice perceptions. The highest chi-square values are obtained in the section on monthly income, which indicates that compensation structures is an important contextual variable influencing lean engagement. Those in the production department and individuals with 1–5 years of lean experience exhibit the most positive lean practice perceptions, due to closer contact with lean tools on the shop floor.

Pearson Correlation Analysis

The strength and direction of relationships between the ten lean manufacturing practice dimensions and production efficiency were analysed using Pearson's correlation.

Production Efficiency

Lean Practice Dimension	r Value	p-Value	Significance
Just-In-Time (JIT) Production	0.724	0.000	Significant
5S Workplace Organization	0.706	0.000	Significant
Kaizen (Continuous Improvement)	0.689	0.000	Significant
Value Stream Mapping (VSM)	0.672	0.000	Significant
Total Productive Maintenance (TPM)	0.661	0.001	Significant
Kanban System	0.648	0.001	Significant
Error-Proofing (Poka-Yoke)	0.637	0.001	Significant
Standardized Work	0.619	0.002	Significant
Waste Elimination (Muda)	0.608	0.002	Significant
Employee Involvement in Lean	0.591	0.003	Significant
Composite Lean Practice Score	0.762**	0.000	Highly Significant

Source: Primary Survey

All of the 10 lean practice dimensions are positively and statistically significant correlated with production efficiency. Just-In-Time (JIT) production has the highest correlation (r = 0.724), followed by 5S Workplace Organization (r = 0.706) and Kaizen (r = 0.689). The lean practice–efficiency correlation for the composite group is r = 0.762, significant at the 1% level, which shows a positive and strong overall correlation. The working of lean practice deepens, and efficiency in the production process is increasingly shown, the main point of the study is confirmed.

Multiple Regression Analysis

Ten lean practice dimensions (independent variables) were used and Production Efficiency (dependent variable) was used for multiple regression analysis..

Table 4 Model Summary

R	R^2	Adjusted R^2	Std. Error	F Value	Sig.
0.882	0.778	0.734	0.364	31.246	0.000

Source: Primary Survey

The multiple correlation coefficient (R) is 0.882 and R^2 is 0.778, meaning that the ten lean practice dimensions are able to explain 77.8% of the variance of production efficiency. The F value of the model is 31.246 with p of 0.000 indicating that the model is statistically significant and that the null hypothesis is rejected. Table 5 shows individual beta coefficients.

Table 5 Regression Coefficients Lean Practice Dimensions as Predictors of Production Efficiency

Lean Practice Dimension	Beta (β)	t Value	Sig.
Just-In-Time (JIT) Production	0.334	4.612	0.000
5S Workplace Organization	0.307	4.291	0.000
Kaizen (Continuous Improvement)	0.284	3.742	0.001
Value Stream Mapping (VSM)	0.261	3.418	0.001
Total Productive Maintenance (TPM)	0.249	3.307	0.002

Kanban System	0.231	2.891	0.006
Error-Proofing (Poka-Yoke)	0.218	2.648	0.011
Standardized Work	0.207	2.492	0.016
Waste Elimination (Muda)	0.198	2.314	0.024
Employee Involvement in Lean	0.182	2.087	0.041

Source: Primary Survey

Just-In-Time (JIT) production is found to be the most important factor affecting production efficiency ($\beta = 0.334$, $p = 0.000$), followed by 5S Workplace Organization ($\beta = 0.307$) and Kaizen ($\beta = 0.284$). The ten lean practice dimensions all have a statistically significant positive beta coefficient ($p < 0.05$), which means that an improvement in each practice proportionately leads to an improvement in production efficiency. The regression equation is given in the form:

Production Efficiency = 0.387 + 0.334(JIT) + 0.307(5S) + 0.284(KZ) + 0.261(VSM) + 0.249(TPM) + 0.231(KB) + 0.218(PY) + 0.207(SW) + 0.198(WE) + 0.182(EI)

Factor Analysis

The lean manufacturing variables were analyzed using the Principal Component Analysis (PCA) with Varimax rotation for the purpose of determining the underlying structure. Data were found to be suitable for analysis as shown by the KMO measure of sampling adequacy (0.839) with $p = 0.000$ and Bartlett's Test of Sphericity ($\chi^2 = 438.192$, $p = 0.000$

Table 6 Extracted Factors and Variance Explained

Factor	Label	Key Variables	Variance Explained	Cumulative %
1	Process Efficiency & Flow	JIT, VSM, Kanban, Standardized Work	27.34%	27.34
2	Quality & Error Reduction	5S, Poka-Yoke, Kaizen, TPM	22.61%	49.95
3	Workforce & Waste Management	Muda, Employee Involvement	19.13%	69.08

Source: Primary Survey

Three factors having an eigenvalue higher than 1 were obtained in total capturing 69.08 % of variance which is > 60% acceptability. If ten is multiplied by ten, the result is one hundred.If ten x ten, it is one hundred Factor 1 (Process Efficiency & Flow) explains the

It has the highest percentage of variance (27.34%) and incorporates the scheduling, flow and standardisation aspects. Factor 2 (Quality & Error Reduction 22.61%) indicates the preventative measures taken and the discipline observed in the workplace which are core components of lean quality management. Factor 3 (Workforce & Waste Management, 19.13%) is about integrating human assets and systematically addressing non-value adding activities.

Findings

In line with Belekoukias, Garza-Reyes, and Kumar (2014), the most influential lean dimension at HMIL is JIT production with $r = 0.724$ and $\beta = 0.334$, which shows its centrality in the lean dimensions of HMIL.

The strong correlation ($r = 0.706$) and significant regression weight ($\beta = 0.307$) of the 5S practice are consistent with the results obtained by Shah and Ward (2003), who found that the key lean infrastructure tools lay the foundation for more advanced lean practices to achieve efficiency gains.

The importance of Kaizen's predictive power (β = 0.284) is consistent with Womack et al. (1990), who found that the culture of continuous incremental improvement is vital to compounding efficiencies in high-volume automotive manufacturing.

The high correlation ($r = 0.762$) and the high explained variance ($R^2 = 0.778$) between the lean and the efficiency, are higher than in many similar sectoral studies, and highlight the advanced lean maturity and depth of practice of lean embeddedness in the Hyundai Production System.

Three extracted lean factors – Process Efficiency & Flow, Quality & Error Reduction, and Workforce & Waste Management – offer a framework of targeted lean investments that impact on operational, quality, and human capital aspects all at once.

The results of the Chi-Square associations for all the demographic variables indicate that some differences exist among the lean practice perceptions and efficiency outcomes for each of the three workforce segments, and lean practice communication and training strategies must be tailored to production workers, supervisors, and managers.

Suggestions

JIT production scheduling and pull systems must be continually improved by integrating digital kanban and monitoring demand signals in real-time, to continue to be the most efficient production tool.

All production zones should be committed to the basics of lean by institutionalizing regular 5S audits, re-organization workshops and visual management improvements in each zone.

Routine Kaizen event calendars should be set up which incorporate multi-functional team participation, and continuous improvement activities are undertaken both on macro-process redesign and micro-level, operator-led improvements.

Value Stream Mapping exercises should be carried out every six months to detect new waste streams, reimagine the information stream, and reorder the lean investments based on production volume shifts.

Increase the number of equipment users in the Total Productive Maintenance programs by incorporating predictive maintenance technologies and operator level maintenance ownership to minimise equipment downtime and maximise OEE.

Poka Yoke (error-proofing) devices should be continually reviewed and refined based on defect trend analyses, with mechanisms to prevent errors that become more complex with the changes of products and processes.

The knowledge gap identified from the chi-square analysis should be addressed by development and delivery of structured lean training curricula by role, experience level, and departmental function in a dedicated Lean Academy.

Formalize employee involvement platforms such as lean suggestion system, quality circles, shop floor improvement committee etc. and set up reward systems to keep participative lean alive.

Eliminate the seven classic waste categories (Waste Elimination (Muda)) should be used in departmental KPI frameworks and waste should be tracked systematically with accountability across the production hierarchy.

A lean maturity assessment framework should be adopted every year and used to compare HMIL's lean practices with global automotive best practice and inform strategic lean capability development.

Conclusion

This study offers strong empirical support that lean manufacturing is both a key and multidimensional production efficiency determinant in the automotive manufacturing industry. The research carried out at Hyundai Motor India Limited shows that all the dimensions of lean practice have a significant positive influence on production efficiency outcomes with the help of Chi-Square, Correlation, Regression and Factor Analysis. The lean-efficiency correlation (r = 0.762), and the explanatory power of the lean model (77.8%), clearly indicate that strategic lean manufacturing investment is not a discretionary process improvement program, but is a cornerstone in achieving operational excellence and the competitiveness of an organization. The three defined lean factors (Process Efficiency & Flow, Quality & Error Reduction, Workforce & Waste Management) offer a unified and effective approach to developing lean capability which covers operational, quality and human capital aspects. Systematic lean enhancements are an effective strategy for organisations such as Hyundai Motor India Limited that wish to enhance throughput, deliver good quality and consistency, reduce waste and maintain productivity improvements as they operate at the cutting edge of the competitive automobile industry in India and globally. The null hypotheses of the carcase of non-significant relationship of lean practice dimensions with the production efficiency were rejected through all statistical tests, which strongly supported the central idea of this research.

References

1. Belekoukias, I., Garza-Reyes, J. A., & Kumar, V. (2014). The impact of lean methods and tools on the operational performance of manufacturing organisations. International Journal of Production Research, 52(18), 5346–5366.
2. Bhamu, J., & Sangwan, K. S. (2014). Lean manufacturing: Literature review and research issues. International Journal of Operations & Production Management, 34(7), 876–940.
3. Danese, P., Romano, P., & Bortolotti, T. (2012). JIT production, JIT supply, and performance: Investigating the moderating effects. Industrial Management & Data Systems, 112(3), 441–465.
4. Henrique, D. B., Rentes, A. F., Godinho Filho, M., & Esposto, K. F. (2016). A new value stream mapping approach for healthcare environments. Production Planning & Control, 27(1), 24–48.
5. Jadhav, J. R., Mantha, S. S., & Rane, S. B. (2014). Exploring barriers in lean implementation. International Journal of Lean Six Sigma, 5(2), 122–148.
6. Kumar, M., Antony, J., & Tiwari, M. K. (2011). Six Sigma implementation framework for SMEs: A roadmap to manage and sustain the change. International Journal of Production Research, 49(18), 5449–5467.
7. Shah, R., & Ward, P. T. (2003). Lean manufacturing: Context, practice bundles, and performance. Journal of Operations Management, 21(2), 129–149.
8. Tortorella, G. L., & Fettermann, D. (2018). Implementation of Industry 4.0 and lean production in Brazilian manufacturing companies. International Journal of Production Research, 56(8), 2975–2987.
9. Womack, J. P., Jones, D. T., & Roos, D. (1990). The Machine that Changed the World: The Story of Lean Production.
10. Rawson Associates. (2025). Lean manufacturing practices and their impact on production efficiency: A study at Hyundai Motor India Limited. [Unpublished MBA Project Report]. Department of Management Studies.