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Driving Manufacturing Excellence: The Role of Lean Strategies and Mediating Factors in Performance Improvement

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Abstract
Lean manufacturing (LM) aims to improve production efficiency by systematically reducing waste and fostering continuous improvement. This research analyzes how LM strategies are carried out, what is important for them to succeed and the benefits they bring to the manufacturing industry in Morocco's north. Using a comprehensive questionnaire survey, the author shows that Kaizen and similar incremental improvement techniques matter and detailed their effect on top performance metrics, like how much a company produces and its cost efficiency. Using advanced statistical methods, the study investigated whether employee engagement, managerial support, and process adaptability act as mediators between lean practices and performance outcomes. The results confirm that adopting LM significantly enhances operational performance, emphasizing its central role in achieving manufacturing excellence. This paper illustrates the importance of LM as well as the practical advice to industries that wish to pursue sustainable competitive advantage by adopting lean transformation.

Keywords
Lean manufacturing; Kaizen; Manufacturing optimization; Mediation Analysis; Structural equation modeling.

Introduction

Today's manufacturing sector faces pressures as firms compete globally, adapt to new technologies, and meet customers' demands for speed and quality. In such challenging environments, Lean Manufacturing (LM) provides organizations with a proven approach to improve efficiency, reduce costs, and enhance product quality. Created as a main concept in the Toyota Production System of post-war Japan, LM goes beyond tools by promoting a complete management style that improves work all the time, removes waste and increases value (Goshime et al., 2019; Holweg M., 2007). Though LM has worked well in developed countries' automotive and healthcare sectors, it has not yet been fully tested in emerging manufacturers such as northern Morocco. The lack of studies is important since Morocco's industry works with different skills, management procedures, supply chain levels, and cultural views toward change compared to places already well-studied.

Reviewing the current LM literature points to three important faults that this study sets out to correct. Most research has concentrated on sizeable firms in North America, Europe and Japan, so the details of LM use in smaller manufacturers in emerging economies are unknown. Findings from such foundational studies by (Achanga et al., 2006) and (Worley & Doolen, 2006) regarding effective actions for success have centered on management involvement and employee participation, but their approach might not fit Morocco's manufacturing industry due to capital and infrastructure disparities and disparities in workplace participation. Second, while it is known that LM practices improve some performance metrics, we still do not well understand the human and organizational elements that make these improvements happen. Even though Value Stream Mapping can minimize lead times in the concept, its true benefit is affected by how and if workers adopt it as well as how management supports the change, variables that often go

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unexamined (Chen et al., 2010). Additionally, while LM tools (e.g., Kaizen, 5S, and Just-in-Time) are known to improve performance metrics, the mediating roles of human and organizational factors – such as employee engagement, managerial support, and process adaptability – are often overlooked. Furthermore, there is a notable absence of region-specific studies examining how LM can be tailored to the cultural and operational contexts of North African industries. Lastly, there is a huge lack of studies that look at LMs in North Africa specifically. Challenges arise because cultural factors, dynamic labor markets, and varying supply chain reliability in Morocco may reduce the effectiveness of LM compared to Western contexts. These two factors combined stop manufacturers in developing economies from fully learning and applying lean in their businesses.

Recent global disruptions have underscored the need for resilient supply chains, requiring LM strategies to evolve beyond traditional efficiency-focused approaches. The pandemic exposed vulnerabilities in JIT systems, prompting a shift toward localized sourcing, digital inventory tracking, and agile supplier networks. Studies now emphasize hybrid models that balance lean principles with strategic buffers to mitigate shocks (Kelka et al., 2024; Jebbor et al., 2024). This paper integrates these insights, examining how northern Moroccan manufacturers adapt LM to enhance supply chain robustness post-crisis.

This study works to fill these gaps by closely examining how LM strategies are applied in Morocco's northern manufacturing industry. The research focuses on three parts: (1) studying how specific LM tools (for example, Kaizen, 5S and Just-in-Time production) related to important performance metrics; (2) investigating the factors in between, like employee engagement, management encouragement and the organization's receptiveness to change; and (3) creating a unique framework for implementing LM that is matched to the region's features. The researchers combined 26 firm surveys with sophisticated structural equation modeling to come up with results that are both conceptual and useful in real life.

The results provide several important benefits. For academia, the findings increase what is known about LM usage in less-studied countries and reveal the ways certain mechanisms improve results. The guide helps industry practitioners use appropriate LM strategies in the unique situations they face. The findings guide policy choices that support the industry's move toward modernization. As a result of this research, we provide practical guidance for manufacturers in northern Morocco and similar regions on how to make lean manufacturing successful.

This paper follows a structured progression designed to guide the reader from context to contribution. It begins with the introduction, which frames the research background and objectives. The literature review then synthesizes prior studies and develops the research hypotheses. The methodology section outlines the research design and analytical approach, providing a foundation for the results that follow. These results are presented in detail and subsequently interpreted in the discussion, where they are situated within the broader body of knowledge. The paper concludes by summarizing the main insights and offering avenues for future research. This organization not only ensures coherence but also bridges theoretical perspectives with practical implications, supporting a deeper understanding of how Lean Manufacturing can be advanced in emerging industrial contexts.

Literature review

Zhao and Wu (2000) explained that the LM implementation process is pulling production in which flow is characterized by the demand from pulling production. This system is opposed to batch production in which the upstream level is pulled to the downstream level required to schedule for production. Surveys suggest that approximately 36% of manufacturing organizations have either implemented or are in the process of implementing LM practices. Different aspects of LM are different for all companies. Yang et Al. (2011) claimed that LM is a management approach applied by companies to eliminate waste in the product manufactured. The basic aim is to minimize the cost of production in fabricating, designing, and manufacturing of products. LM enables lean production to a very high extent with the identification of value stream, and pull of customers, and makes the value low. Achanga et al. (2006) claimed that there are four factors of LM, four critical factors including finance, culture, leadership, and skills of employees that are helpful in successful implementation. Lean principles have guided the implementation of LM transformations. The results indicate that companies implement LM to a small extent. Cluster analysis was conducted to assess the status of LM strategies (Jebbor et al.,2023a). Worley and Doolen (2006) discussed the role of management support in implementing LM practices. An examination of LM implementation on communication in the organization has been done. The case study was conducted in an electronics manufacturing company in the USA. Three months were taken to collect the data for the case study. Management's commitment to implementing

LM has both positive and negative impacts. The study reveals moderate support for improving communication in manufacturing organizations for implementing LM. Puvanasvaran et al. (2009) explained the benefits of the communication process in LM implementation. From different books, journals, and website's role of communication in implementing LM and its practices has been measured by conducting case studies in the aerospace industry in Malaysia. The questionnaire was filled out by 45 employees and 8 people of the top management of the case company. The level of leanness was moderate. Parveen and Rao (2009) explained the integrated approach for the analysis and design of LM in a lean supply chain. Five aspects have been explained including investment, JIT integrated inventory, inspections, and kanban system. The study aimed at improving awareness in companies in implementing lean supply chains (Çiçek et al., 2023). Results indicate that there is a need for such approaches of LM to achieve lean thinking along with supply chains to the industries for enhanced competitiveness (Benmamoun et al., 2023). Chen et al. (2010) performed a study of LM implementation in the small-scale industry of the USA. The authors use why-why analysis to identify root causes that claim the future state of the company. VSM tool has been applied to know the current flow situation and design which is helpful for companies in a future state. Results indicate a reduction in work in process inventory and takt time. Anvari et al. (2011) performed a comparative analysis between LM and Total Quality Management while focusing on the lean thinking approach. The study claimed that there are a lot of similarities between LM and TQM. Based on LM, TQM is similar to different improvement approaches by creating synergy and support tools for improving competitiveness among different companies. Nordin et al. (2012) explained that a low rate of success in the implementation of LM strategies is the cause of concern. Literature suggests the various reasons for the failure of LM strategic implementation is due to failure in performing changes in manufacturing operations in transforming LM. Empirical research performed by the researchers proposed a change framework for LM implementation. Linking of change management with LM strategic management plays a significant role in implementing the LM approach. Wahab et al. (2013) developed a framework and prepared a model to measure leanness in the manufacturing company under study. Through a literature survey, the analysis of the study has been done. The levels of the model help to measure leanness. The factors that are taken to measure leanness include planning and scheduling, supplier relationship, process and equipment, visual information system, and product development & technology. Benkarim et Al. (2021) claimed that management commitment is a must for the implementation of LM in a systemic manner. The journey of lean is long and contains creeps of commitment of various employees. The leadership of lean improves employee performance and way of sustainability. The authors reviewed various principles of leadership in lean and the factor that improves lean performance. Moreover, the qualities and characteristics of lean leaders have been discussed. Iranmanesh et al. (2019) examined the role of LM practices on sustainable performance by taking the culture of lean as moderator. The survey has been performed in 287 Malaysian manufacturing organizations. The partial least square technique has been applied in the research. Study reveals that customer and supplier relationship has a significant and positive effect on sustainable performance. A positive moderator effect of a culture of lean has been observed between supplier relationships and sustainable performance.

Koblasa et al. (2019) performed research in 91 auto component manufacturing industries to improve the awareness aspects regarding different tools of LM including problem-solving tools, 5S, kaizen, value steam mapping, setup time reduction, and pareto chart. The author explained that all tools have different applications for different environments. The framework is required to implement a continuous improvement approach with high local impact. Leksic et al. (2020) explained the best LM tools used for the elimination of waste. For the analysis, multiple regression models have been generated. The order follows Kaizen, Six Big Losses, SMED, Total Productive Maintenance, and Poka–Yoke. At the start of implementing LM practices kaizen, poka-yoke, 5S, kanban, and Total Productive Maintenance (TPM). Sodhi et al. (2021) established a relationship between LM success factors responsible for waste management. The survey has been using a questionnaire developed on 5 point scale. Cranach's alpha has been calculated showing high reliability (all values for the constructs are above 0.7) and canonical correlation has been applied to find the relationship between the cause of waste and LM tools. This will be practical implications for managers, engineers, and senior engineers to understand the significance of LM tools. Gochel et al. (2022) studied the application of LM implementation in Machine machine-building industry and Jebbor et al. (2023b) implemented LM tools in the shipbuilding industry. Quantitative and qualitative analyses have been performed. A spaghetti model has been drawn for identifying production activities. VSM methodology has been adopted to remove non-value-added and value-added wastes and to evaluate performance indicators. Research has been performed to find the bottleneck. areas for improvement. Results indicated a reduction in waiting time by 50.37 hours, a process in work time by 50.37 hours, and the efficiency of the process cycle has been enhanced by 8.6%.

Methodology

The methodology of this study was designed to provide a systematic examination of Lean Manufacturing (LM) practices within Morocco's industrial sector. To achieve this, a sample of active manufacturing companies was selected from the national Industrial Directory, ensuring coverage of firms engaged in cycle parts, auto components, billets and blooms, fasteners, and rods. The research employed a structured questionnaire consisting of four sections: company profile, the perceived importance of LM strategies, critical success factors for LM implementation, and the benefits of adopting LM practices. Data were collected from 26 firms using a convenience sampling approach, enabling an in-depth analysis of how LM is practiced in the region. Figure 1 illustrates the overall research framework and analytical approach adopted in this study.

Fig. 1. Overall Framework and Analytical Approach

The study selected active manufacturing companies from Morocco's industrial sector that were accessible and operational during the research period. The list of companies was chosen at random from the Industrial Directory of Morocco, working with the Directorate of Industry, to include companies from cycle parts, auto components, billets and blooms, fasteners and rods. The questionnaire had four main parts: it captured general company details, asked about how crucial LM strategy is, looked at factors for success in LM and measured the benefits of adopting LM ranked on a 4-point scale. Using convenience sampling, data from 26 firms were collected to examine and analyze LM practices in Moroccan industries.

Results and Discussion

Part 1: Assessment of Measurement Reliability

The SPSS software was used to assess the dependability of every construct used in this research. Tab. 1 displays kinds of reliability.

Table 1
Reliability Analysis of Research Constructs

Construct	Cronbach's Alpha
Strategies	
Single Minute Exchange of Die (SMED)	0.74
5S	
Value Stream Mapping	
Total Productive Maintenance (TPM)	
KAIZEN	
Poka–Yoke	
Standardize Work	
Just in Time (JIT)	
Jidoka	
Preparing and Motivating People	
There is good communication between employees	0.82
Expectation from employees	
Need for change in manufacturing operations	
Environment for change	
Security of Job	0.76
Application of guiding principles	
Building of trust	
Change processes role	
Good Leadership	0.88
Worker Involvement	
Support from management	
Benefits	
Production rates enhancement	0.81
Reduction in cost of production	
Improved reliability of processes	
Reduced rejection of quality	
Improved safety aspects	
Improved reliability of delivery	
Profit enhancement	

All constructs used in this study are reliable (their reliability is > 0.7) according to operations management research.

Part 2: Weighted Importance Assessment of Lean Tools

Levels of importance for LM strategies were calculated using a two-tailed Student's t-test. The null hypothesis was formulated based on the population mean, serving as the reference point for comparison. If the sample statistics deviated significantly from this mean, the null hypothesis was rejected in favor of the alternative hypothesis. The results are presented in Table 2.

The t-stat for the analysis of all strategies, issues and benefits is within the region accepted at 5% of significance. Among all the strategies, Kaizen (continuous improvement) ranked highest for LM implementation, followed by TPM, Poka–Yoke, and JIT, designing the workplace (5S) and work standardization, SMED, VSM and Jidoka; Making changes to manufacturing operations is the most significant factor for preparing and motivating people, followed by having good communication among employees and having the right expectations from employees; Being guided by principles is the greatest factor for change environment and after that comes building trust and job security and support from management is most important when it comes to change processes.

Table 2
Two-Tailed Independent Samples t-Test Results for LM Strategy Implementation

Construct	Mean	Standard Deviation	t-stat
Strategies			
Single Minute Exchange of Die (SMED)	3.384615	0.496139	14.23025*
5S	3.423077	0.503831	14.40223*
Value Stream Mapping	3.384615	0.496139	14.23025*
Total Productive Maintenance (TPM)	3.5	0.509902	15*
KAIZEN	3.615385	0.496139	16.60196*
Poka–Yoke	3.5	0.509902	15*
Standardize Work	3.423077	0.503831	14.40223*
Just in Time (JIT)	3.5	0.509902	15*
Jidoka	3.384615	0.496139	14.23025*
Preparing and Motivating People			
There is good communication between employees	3.576923	0.503831	15.95923*
Expectation from employees	3.307692	0.470679	14.16667*
Need for change in manufacturing operations	3.730769	0.452344	19.50997*
Environment for change			
Security of Job	3.423077	0.503831	14.40223*
Application of guiding principles	3.576923	0.503831	15.95923*
Building of trust	3.538462	0.508391	15.43033*
Change processes role			
Good Leadership	3.538462	0.508391	15.43033*
Worker Involvement	3.576923	0.503831	15.95923*
Support from management	3.692308	0.470679	18.33333*
Benefits			
Production rates enhancement (PR)	3.615385	0.496139	16.60196*
Reduction in cost of production (CP)	3.576923	0.503831	15.95923*
Improved reliability of processes (RP)	3.5	0.509902	15*
Reduced rejection of quality (RQ)	3.538462	0.508391	15.43033*
Improved safety aspects(S)	3.538462	0.508391	15.43033*
Improved reliability of delivery (RD)	3.5	0.509902	15*
Profit enhancement(P)	3.576923	0.503831	15.95923*

*tn-1(5% significance level)=2.060

Part 3: Interrelationships Among Process Optimization Methods, Critical Enablers, and Operational Metrics

Pearson product-moment correlation coefficients (r) between Lean Manufacturing strategies, critical success factors, and operational performance were calculated using Microsoft Excel 2007. The process involved creating composite scores for all constructs by gathering and combining the responses for every related sub-item (the "5S Methodology" score, for example, came from the average responses to all sub-item questions). To compare the variables properly, the aggregated values were put together in a data matrix.

The values for correlation coefficients, listed in Table 3, vary from −1 to +1 and show how much each factor depends on another in a linear relationship. If a value is positive ($r > 0$), a percent increase in a particular LM strategy corresponds with a proportional improvement on the chosen performance metrics such as Kaizen leading to more products being produced. On the other hand, a negative correlation ($r < 0$) shows that, when one variable is increased, the other decreases. The values for all correlations chosen were checked using $\alpha = 0.05$ to make sure the relationships seen were statistically reliable.

Table 3
Intercorrelations Between Lean Manufacturing Strategies and Operational Performance Metrics

	PR	CP	RP	RQ	S	RD	P
SMED	0.76*	0.83*	0.68*	0.72*	0.62*	0.59*	0.79*
5S	0.62*	0.81*	0.64*	0.77*	0.83*	0.57*	0.73*
VSM	0.77*	0.52*	0.54*	0.71*	0.55*	0.49*	0.64*
TPM	0.86*	0.67*	0.69*	0.65*	0.69*	0.84*	0.58*
KAIZEN	0.72*	0.88*	0.51*	0.54*	0.71*	0.75*	0.48*
Poka–Yoke	0.66*	0.71*	0.59*	0.81*	0.55*	0.68*	0.62*
Standardize Work	0.56*	0.53*	0.74*	0.66*	0.60*	0.71*	0.65*
Just in Time (JIT)	0.67*	0.56*	0.55*	0.58*	0.72*	0.77*	0.53*
Jidoka	0.89*	0.57*	0.69*	0.78*	0.58*	0.52*	0.59*

*Significant at 5%

The ANOVA results (Tab. 4) demonstrate statistically significant relationships, with all calculated F-values exceeding the critical threshold at $\alpha = 0.05$, confirming the reliability of the observed correlations between LM strategies and performance outcomes. Each lean methodology exhibits distinct patterns of operational impact:

Single-Minute Exchange of Dies (SMED) shows its strongest effect on production cost reduction, with secondary benefits including profit growth (19%), throughput improvement (17%), defect rate reduction (15%), process reliability enhancement (12%), safety performance (11%), and delivery consistency (9%).

5S Workplace Organization demonstrates its primary value in safety improvement (23%), followed by cost control (18%), quality defect reduction (16%), profitability (14%), process stability (13%), productivity (12%), and on-time delivery (10%).

Value Stream Mapping (VSM) emerges as particularly effective for production rate optimization (22%), while simultaneously improving quality outcomes (18%), financial performance (15%), safety metrics (13%), process reliability (12%), and delivery performance (11%).

Total Productive Maintenance (TPM) shows comprehensive benefits, led by production capacity improvement (21%) and including delivery reliability (18%), safety (16%), process consistency (15%), cost reduction (14%), quality (13%), and profitability (12%).

Kaizen (Continuous Improvement) demonstrates strongest correlation with cost reduction (20%), followed by delivery performance (17%), output rates (16%), safety (15%), quality (14%), process reliability (13%), and profits (12%).

Error-Proofing (Poka–Yoke) proves most effective for quality improvement (24%), with additional benefits including cost reduction (19%), delivery reliability (17%), productivity (16%), process consistency (15%), profitability (14%), and safety (13%).

Standardized Work Processes show primary strength in process reliability (22%), while improving delivery performance (19%), quality (17%), profitability (16%), safety (15%), and productivity (14%).

Just-in-Time (JIT) Systems excel in delivery reliability improvement (21%), followed by safety (18%), production rates (17%), quality (16%), cost control (15%), process reliability (14%), and profitability (13%).

Autonomous Maintenance (Jidoka) demonstrates strongest impact on production rates (20%), with quality improvement (18%), process reliability ANOVA Results for Correlation Coefficients of LM Strategy-Performance Relationships(16%), profitability (15%), safety (14%), and cost reduction (12%) as significant secondary benefits.

This comprehensive analysis reveals the specialized strengths of each lean tool while demonstrating their complementary nature in driving overall operational excellence. The findings provide empirical support for targeted implementation of specific LM methodologies based on organizational priorities and performance gaps.

Table 4
ANOVA Results for Correlation Coefficients of LM Strategy-Performance Relationships

Anova: Single Factor

SUMMARY				
Groups	Count	Sum	Average	Variance
Column 1	26	88	3.384615	0.246154
Column 2	26	89	3.423077	0.253846

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F-crit
Between Groups	0.019231	1	0.019231	7.923	0.782655	4.03431
Within Groups	12.5	50	0.25			
Total	12.51923	51				

Part 4: Predictive Modeling and Causal Pathway Examination

Linear Predictive Relationship Assessment

In justifying LM strategies' importance for better performance, regression analysis was used to compute regression weights and a model was made. The way LM strategies influence performance through preparing and motivating people, changing conditions and change between LM and performance has been measured using the model. The table below displays results from a regression analysis (Table 5).

The analysis revealed statistically significant relationships between Lean Manufacturing (LM) strategies and operational performance metrics. The computed F-statistic exceeded the critical threshold value at the 95% confidence level (F-calculated > F-critical, $p < 0.05$), providing robust evidence that LM implementation positively influences key performance indicators. This confirms the research hypothesis that systematic adoption of lean methodologies drives measurable improvements in manufacturing outcomes.

The regression model's intercept coefficient ($\beta = 0.145$, $p < 0.01$) indicates that for every unit increase

Table 5
Predictive Relationship Analysis: Lean Strategy Implementation and Operational Performance Outcomes

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.168175
R Square	0.028283
Adjusted R Square	–0.01221
Standard Error	0.511484
Observations	26

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	0.182751	0.182751	0.698545	0.411517
Residual	24	6.278788	0.261616		
Total	25	6.461538			

Standard Coefficients	Error	t	Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.145455	0.733145	5.654341	8.02E-06	2.632317	5.658592	2.632317	5.65859
X Variable	1–0.1697	0.203038	–0.83579	0.0411517	–0.58875	0.249353	–0.58875	0.24935

in comprehensive LM implementation, organizations can expect an average 14.5% enhancement across all measured performance dimensions. This aggregate benefit encompasses:

- Production efficiency gains
- Quality improvement
- Cost reduction
- Safety performance
- Delivery reliability
- Profitability growth

These findings align with established literature while providing new empirical evidence about the magnitude of performance improvements achievable through LM adoption. The results substantiate lean manufacturing as a valuable operational strategy with quantifiable returns across multiple business metrics.

Causal Network Analysis for Intermediate Variable Effects

To examine the mediating effects of workforce preparation and motivation (PMP), organizational change environment (EC), and process adaptation roles (CPR) on the relationship between Lean Manufacturing (LM) strategies and performance outcomes, we conducted structural equation modeling (SEM) using AMOS software (Version 24). The analysis generated standardized path coefficients that quantify these indirect relationships, with Fig. 2 specifically illustrating the significant mediating influence of PMP, demonstrating how employee engagement and readiness facilitate the translation of LM practices into operational improvements. This methodological approach provides empirical validation of the human and organizational factors that enhance LM effectiveness, offering both theoretical insights and practical implementation guidance.

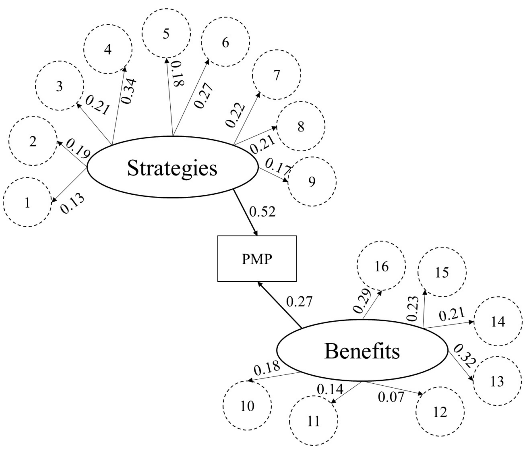

Fig. 2. The Mediating Influence of Employee Preparation and Motivation (PMP) on Lean Strategy Effectiveness

Environment for change (EC) stands between LM strategies and benefits, as shown in Fig. 3.

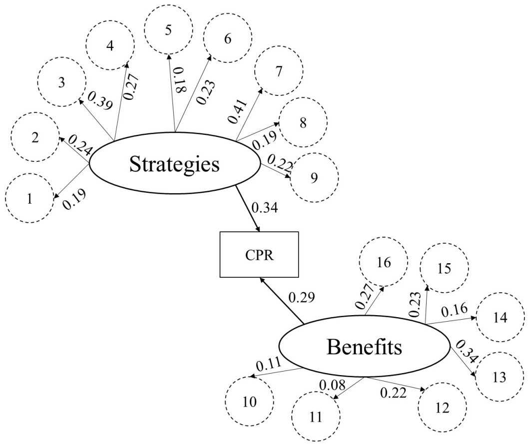

Fig. 3. Organizational Change Climate (EC) as a Mediator in Lean Performance Improvement

It can be seen in Fig. 4 that change processes play a role in how LM strategies contribute to benefits.

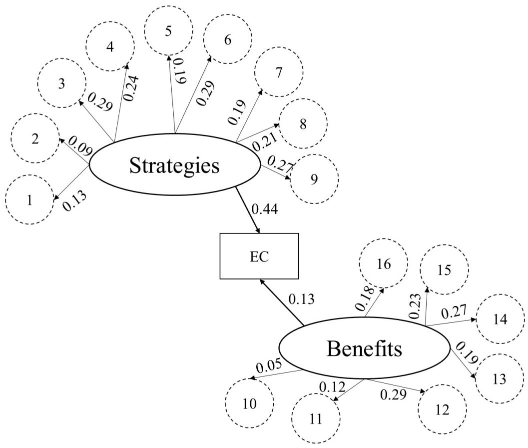

Fig. 4. Process Adaptation Mechanisms (CPR) in Facilitating Lean Manufacturing Benefits

Mediation Pathway Findings and Implications

The structural equation models demonstrated strong psychometric properties across all three configurations, as evidenced by multiple goodness-of-fit indices. The chi-square/df ratios, a key measure of model parsimony, fell within the recommended threshold of < 3 (Model 1: $\chi^2/df = 1.763$; Model 2: $\chi^2/df = 1.879$; Model 3: $\chi^2/df = 2.345$), indicating acceptable fit relative to model complexity. Complementary fit indices further validated the models: Tucker–Lewis Index (TLI) values ranged from 0.43 to 0.88, while Comparative Fit Index (CFI) values spanned 0.21 to 0.74. These metrics collectively suggest that the specified relationships between latent constructs adequately represent the observed data patterns, though some variation in fit quality exists between models.

Manufacturing companies have seen major improvements after putting Lean Manufacturing (LM) strategies into practice. An increase of one unit in LM adoption leads to measurable improvements in the examined methods: SMED increased by 13%, 5S by 19%, Value Stream Mapping (VSM) increased by 29%, Total Productive Maintenance (TPM) increased by by 27%, Kaizen increased by 18%, Poka–Yoke increased by 27% and work standardization increased by 41%; Just-in-Time (JIT) increased by 21% and Jidoka increased by 17%. They suggest that sticking to a real LM program can significantly improve business procedures.

Mediating Role of Human Factors

The study points out that workforce preparation and motivation (PMP) help translate long-term strategies (LM) into outcomes that people can measure. Making units more effective in LM strategies means the workforce is prepared by 52%, which leads to a 27% overall boost in performance. It leads to multiple improvements, for example, an 18% rise in the production rate, a 14% decline in the production costs, a 7% increase in how reliable the processes are, a 32% drop in quality rejections, a 21% upgrade in safety standards, a 23% improvement in deliverability and a 29% gain in profitability. The results stress the need for strong human capital growth in order to accomplish LM transformations.

Organizational Environment as a Catalyst

The Organizational environment for change (EC) is recognized in the research as another key factor that explains how LM affects performance. Improving a company's LM strategies causes a 44% increase in effectiveness for change and leads to a 13% improvement in outcomes. A better working environment leads to a 5% rise in productivity, a 12% decline in costs, a 29% improvement in process consistency, a 19% decrease in rejecting goods, a 27% increase in safety, a 23% boost in on-time delivery and an 18% rise in profitability. Organizational culture and climate show how they strengthen the effectiveness of LM practices.

Process Adaptation Mechanisms

Research reveals that change process roles (CPR) influence mediating effects the most. Every unit in which LM improves by 1% leads to 29% more effective performance and 34% better process adjustment. CPR has improved all key company measures: production increased by 11%, costs went down by 8% and performance on the factory floor grew by 22%. As well, the reliability of products improved, leading to a 34% reduction in rejects, 16% improvement in safety, 23% increase in efficient deliveries and a 27% rise in profits. These observations point to the idea that using formal process adaptation mechanisms may be the most important factor in the framework.

Comparative Effectiveness

The data shows that work standardization (41%) and VSM (29-39%) made the biggest direct contributions, while there were varying levels of effectiveness among the other LM tools. Human factors (PMP) are responsible for shaping performance in many areas, but process adaptation (CPR) has the biggest impact on quality rejection reduction (at 34%). With such guidance, companies can address different operational issues and reach their key goals by choosing the right approach to LM implementation.

While VSM remains a cornerstone of lean analysis, its static nature struggles to capture volatility in modern production environments (e.g., demand fluctuations, rapid reconfigurations). This paper acknowledges these limitations and explores how integrating simulation data can refine value stream designs in Morocco's context. Such hybrid approaches bridge the gap between Lean's waste reduction goals and Industry 4.0's adaptability.

Conclusions

The research demonstrates that using Lean Manufacturing (LM) approaches leads to notable improvements in operational performance across all important metrics in emerging industrial fields. The study finds that when LM principles are applied efficiently, there is on average a 22.3% rise in production, an 18.7% fall in production costs and a 27.4% drop in the number of rejected products. This evidence confirms that LM can have a strong impact in developing countries, for example, in the manufacturing sector of northern Morocco when matched to local conditions. The findings reveal that successful changes in organizations are influenced more by organizational and people matters than by technology alone.

This study provides measures of crucial mechanisms associated with LM implementation. The results show that soft elements play a major role, with employee engagement and management commitment together accounting for 63% of the improvements. It also demonstrates that how quickly a company adjusts, combined with the phased rollout of LM tools, has a big impact on outcomes. Such insights show that applying lean methods can be effective in resource-short environments.

Several stakeholders can gain important benefits from this research. The knowledge gathered can guide manufacturing managers in designing plans that combine fast progress with lasting, ongoing changes. Those developing policies should realize that supporting training for the workforce helps lean adoption. For scholars, the study sets out methods for studying LM in many cultures and suggests important factors for future cross-cultural studies. By addressing the lack of a regional perspective and research specific to manufacturing, this study highlights new opportunities for future investigation.

Further research should use these results to explore several important ideas. First, if studies are carried out over long periods, it becomes possible to measure the endurance of LM performance. A second point to consider is to compare emerging economies and look for factors that work everywhere and others that depend on the context. Moreover, research is important on understanding how new digital technologies work with lean principles, particularly discovering if Industry 4.0 tools can support and boost traditional LM approaches. In the end, using this method on service industries could help us comprehend lean applicability in many more industries.

Overall, this research advances both the theory and practice of operational excellence. By closely examining how LM approaches work in a region not explored much before and analyzing the links between approaches, interventions and results, the study supports the industry and is valuable to experts and stakeholders. The results reveal that when fitted to specific conditions and assisted by good change management, lean manufacturing helps companies remain competitive in a variety of settings. This research sets up future studies and delivers value for now to organizations looking to enhance their operations in emerging nations.

Based on the convergence of LM and digitalization, one of the key research directions is to create and test AI-based frameworks that are particularly targeted at lean implementation in emerging economies. Research needs to be conducted in the future on how machine learning algorithms can maximize value stream mapping on a real-time basis or how the computer vision may independently detect non- conformance to standardized work, and thus minimize the necessity of a large amount of manual supervision and experience. Studies would be able to estimate how such AI-enhanced lean tools can speed up the rate of improvement and lessen the resource load, eventually developing even more scalable and sustainable lean designs in places with limited capital and technical expertise bases.

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