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Effects of Lean Manufacturing Implementation, Raw Material Quality, and Employee Training on the Success of Manufacturing Firms

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ABSTRACT

This study examines the impact of Lean Manufacturing implementation, Raw Material Quality, and Employee Training on the success of manufacturing companies through a quantitative analysis. Data was collected from 220 manufacturing firms, utilizing a Likert scale ranging from 1 to 5 to measure the variables in question. Structural Equation Modeling with Partial Least Squares (SEM-PLS) was employed to analyze the data. The results reveal that Lean Manufacturing, Raw Material Quality, and Employee Training all have positive and significant effects on the success of manufacturing firms, with Lean Manufacturing emerging as the most influential factor. The findings suggest that a holistic approach, integrating lean practices, high-quality raw materials, and continuous employee development, is essential for achieving superior performance in the manufacturing sector. This study contributes to the literature by providing empirical evidence on the synergistic effects of these critical factors and offers practical insights for industry practitioners and policymakers.

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1. INTRODUCTION

In today's highly competitive global marketplace, manufacturing companies are increasingly adopting lean manufacturing practices to enhance operational efficiency, product quality, and overall competitiveness. Lean manufacturing focuses on eliminating waste, optimizing processes, and fostering a culture of continuous improvement, which involves all employees in the organization [1]. This approach not only reduces production costs but also improves productivity and product quality through standardized work and Kaizen [1]. The integration of lean principles into supply chain operations further enhances value creation by streamlining processes, reducing costs, and improving overall efficiency, as evidenced by significant improvements in supply chain performance metrics such as lead time, inventory levels, and defect rates [2]. The versatility of lean methodologies across various industries, including their successful application in companies like AeroStar, Nova Poshta, and Boeing, underscores their effectiveness in driving cost savings, productivity enhancements, and improved product quality [3]. Additionally, lean manufacturing emphasizes the rational use of resources and the elimination of various types of losses, such as overproduction, unnecessary movement of materials, and excessive stocks, which are critical for maintaining a competitive edge [4]. The implementation of lean practices has also led to substantial reductions in inventory levels and better utilization of financial, material, and human resources, as demonstrated by a case study where inventory levels were reduced from 408 to 0 sleeves, freeing up significant floor space [5]. Concurrently, the quality of raw materials is crucial for ensuring the consistency and reliability of final products, which is essential for maintaining customer satisfaction and competitive advantage. Therefore, the combination of lean manufacturing practices, high-quality raw materials, and comprehensive employee training is pivotal for manufacturing companies aiming to thrive in the global market.

Employee training is indeed a critical factor in the success of manufacturing companies, especially in an era marked by rapid technological advancements and evolving production processes. Effective training programs are essential for equipping employees with the skills needed to operate advanced machinery, adhere to stringent quality standards, and adapt to new production methods. This continuous development ensures that employees can contribute to the company's competitiveness and innovation. For instance, training helps bridge the gap between current and desired performance by providing the necessary knowledge and skills, thereby improving overall productivity and work performance [6], [7]. Moreover, in the context of learning organizations, employee training and development play a pivotal role in fostering a culture of continuous improvement and adaptability, which is crucial for implementing innovative practices such as lean manufacturing [8]. The alignment of training programs with business needs and the strategic goals of the organization further enhances their effectiveness, ensuring that both organizational and individual employee needs are met [9]. In industries like apparel manufacturing, where skilled labor is essential for producing high-quality products, effective training programs can significantly reduce waste and increase production efficiency, thereby ensuring that the quality of raw materials is maximized in the production process [10]. Additionally, the support from top management and the integration of training with business strategies are vital for the successful implementation of these programs, as they help create a positive organizational culture that values continuous learning and development [8].

This study aims to explore the combined effect of lean manufacturing implementation, raw material quality, and employee training on the success of manufacturing companies.

2. LITERATURE REVIEW

2.1 Lean Manufacturing Implementation

Lean manufacturing, originating from the Toyota Production System (TPS), has been widely adopted globally to minimize waste and maximize efficiency in manufacturing processes. Core principles such as just-in-time production, continuous improvement (Kaizen), and value stream mapping (VSM) are central to this methodology, aiming to streamline operations, reduce costs, and enhance product quality. Studies have shown that lean manufacturing significantly improves various performance metrics, including productivity, lead time, and defect rates. For instance, research highlights that lean practices like production flow management and customer focus are significantly related to operational performance, with large enterprises benefiting more from production flow management and SMEs from customer focus [11]. Additionally, VSM is a crucial tool for diagnosing and implementing lean practices, helping to identify and eliminate waste, thereby improving lead time and the value-added ratio (VAR) [12].

Practical applications of lean principles have led to substantial improvements in real-world scenarios, such as a 100% reduction in inventory levels and a 22% decrease in space utilization in a manufacturing company [5]. The versatility of lean methodologies across various industries and administrative processes is also emphasized, with strong leadership commitment and organizational culture being critical for successful lean transformations [3]. Furthermore, the comparative analysis between the USA and African industrial landscapes reveals that while lean manufacturing has significantly transformed the American industrial sector, its application in Africa is influenced by unique socio-economic and infrastructural challenges. However, both regions benefit from the principles of waste reduction, continuous improvement, and enhanced efficiency, with technology and innovation playing a pivotal role in shaping the future of lean practices [13]. Despite the extensive research on lean manufacturing, there remains a gap in understanding its interaction with other factors, such as raw material quality and employee training, in determining the overall success of manufacturing companies. This study seeks to address this gap by examining the combined effect of these variables.

2.2 Raw Material Quality

The quality of raw materials is indeed a critical determinant of the final product's quality, significantly influencing customer satisfaction and the company's reputation in the market. High-quality raw materials ensure consistency in production, minimize defects, and reduce rework and waste, which are essential for manufacturing success, especially in industries where precision and reliability are paramount. Material Requirement Planning (MRP) systems play a crucial role in managing the quality and quantity of raw materials, ensuring that the right materials are available at the right time to meet production demands without overstocking or understocking. In large-scale industries like steel manufacturing, optimizing raw material purchasing is vital for cost savings and maintaining a steady supply, which directly impacts the quality of the final product [14].

Furthermore, the push towards green and digital transformations highlights the importance of using high-quality, sustainable raw materials to meet environmental and economic goals, thereby enhancing the overall quality and sustainability of the final products [15]. Effective inventory control methods, such as the Economic Order Quantity (EOQ) model, can significantly improve the efficiency of raw material management, ensuring that high-quality materials are available when needed without incurring excessive storage costs [16]. For instance, a case study at PT. "X" demonstrated that applying the EOQ method led to substantial cost savings and more efficient raw material inventory control, which is crucial for maintaining production quality and consistency [17]. While the significance of raw material quality is well-documented, its interaction with lean manufacturing practices and employee training in driving manufacturing success has not been thoroughly explored. This research aims to fill this gap by investigating how these factors jointly contribute to the overall success of manufacturing firms.

2.3 Employee Training

Employee training is indeed a critical component in the success of manufacturing companies, especially in an era marked by rapid technological advancements and increasing complexity in production processes. Effective training programs are essential to equip employees with the necessary skills and knowledge to operate sophisticated machinery, adhere to stringent quality standards, and implement innovative practices such as lean manufacturing. Training programs help bridge the gap between current and desired performance by providing employees with the requisite competencies to perform their tasks efficiently and effectively [6]. Moreover, training initiatives have been shown to significantly enhance employee performance, job satisfaction, and adaptability to change, which are crucial for maintaining competitiveness in the dynamic business environment [18]. In the context of manufacturing, where precision and adherence to quality are paramount, continuous employee development ensures that the workforce remains proficient in the latest technologies and methodologies, thereby contributing to increased productivity and profitability [8], [18].

However, the implementation of training programs is not without challenges, such as cost and resource allocation, measuring return on investment, and overcoming employee resistance to change [8]. Despite these challenges, the benefits of training are manifold, including improved employee retention, innovation, and overall organizational success [18], [19]. In the pharmaceutical sector, for instance, research has shown a positive correlation between training and enhanced employee performance, underscoring the importance of a structured training process [20]. Top management support and the integration of training with business strategies are also crucial for the successful implementation of training programs, fostering a culture of continuous learning and development within the organization [8], [19]. This underscores the importance of aligning training programs with lean manufacturing initiatives to maximize their impact on company performance.

2.4 Theoretical Framework

The theoretical framework for this study is grounded in the resource-based view (RBV) of the firm, which posits that a company's resources and capabilities are key determinants of its competitive advantage and performance [21]. Lean manufacturing, raw material quality, and employee training can be viewed as strategic resources that, when effectively leveraged, contribute to superior performance outcomes.

Lean manufacturing represents a set of capabilities that enable firms to optimize their production processes and reduce waste, thereby enhancing efficiency and competitiveness. Raw material quality serves as a critical input that directly impacts the quality and reliability of the final product. Employee training, meanwhile, enhances the firm's human capital, equipping workers with the skills and knowledge needed to implement lean practices and ensure high-quality production.

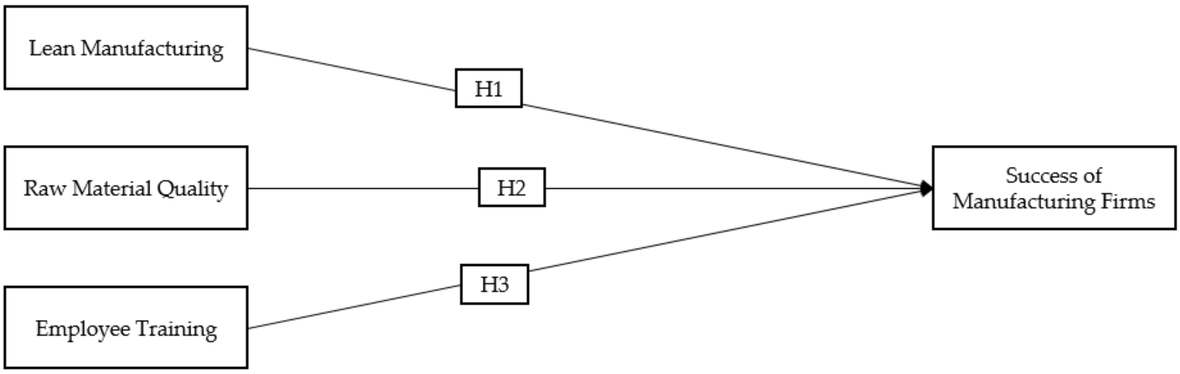

Figure 1. Conceptual Framework

3. METHODS

3.1 Research Design

The study adopts a quantitative research design, which is suitable for examining the relationships between the independent variables (lean manufacturing implementation, raw material quality, and employee training) and the dependent variable (success of manufacturing companies). A cross-sectional survey method was employed to collect data from manufacturing firms. The quantitative approach allows for the statistical testing of hypotheses using large-scale data and provides generalizable findings.

3.2 Sample Selection

The sample for this study consists of 220 manufacturing companies, selected through a purposive sampling technique. The companies were chosen based on their implementation of lean manufacturing practices, their emphasis on raw material quality, and their investment in employee training programs. The sample size of 220 is considered adequate for the application of Structural Equation Modeling with Partial Least Squares (SEM-PLS) analysis, ensuring the reliability and validity of the results.

3.3 Data Collection

Data was collected using a structured questionnaire, designed to measure the key variables of the study. The questionnaire was distributed to managers and senior employees involved in operations, quality control, and human resource management within the selected manufacturing firms. The respondents were asked to rate their perceptions of lean manufacturing implementation, raw material quality, and employee training, as well as the overall success of their company, using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The questionnaire was pre-tested with a small group of respondents to ensure clarity and relevance. Based on the feedback received, minor revisions were made to the wording of some questions to improve comprehension. The final questionnaire was then distributed, and a total of 220 responses were received, representing a 100% response rate.

3.4 Data Analysis

The data collected from the survey was analyzed using Structural Equation Modeling with Partial Least Squares (SEM-PLS) version 3.0. SEM-PLS is a robust statistical technique that is well-suited for complex models with multiple constructs and is particularly effective in handling small to medium sample sizes. The use of SEM-PLS allows for the simultaneous estimation of the measurement model (which assesses the reliability and validity of the constructs) and the structural model (which tests the hypothesized relationships between the constructs).

Measurement Model Assessment: The reliability and validity of the measurement model were assessed by examining the factor loadings, composite reliability (CR), and average variance extracted (AVE) for each construct. Convergent validity was confirmed if the factor loadings were above 0.7, the CR values exceeded 0.7, and the AVE values were greater than 0.5. Discriminant validity was assessed using the Fornell-Larcker criterion, ensuring that each construct was distinct from the others.

Structural Model Assessment: The structural model was evaluated by examining the path coefficients, t-values, and R^2 values to test the hypothesized relationships between lean manufacturing implementation, raw material quality, employee training, and the success of manufacturing companies. Bootstrapping with 5,000 resamples was used to assess the significance of the path coefficients. The R^2 values indicated the amount of variance explained by the independent variables, providing insights into the model's explanatory power.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The descriptive statistics for the key variables—lean manufacturing implementation, raw material quality, employee training, and manufacturing company success. The mean scores for all variables indicate a generally positive perception among respondents, with mean values ranging between 3.8 and 4.3 on a Likert scale of 1 to 5. The standard deviations are relatively low, suggesting consistency in the responses.

The sample in this study includes a balanced representation of small, medium, and large manufacturing companies, with the largest proportion (43.2%) coming from medium-sized companies with 51 to 200 employees. Industry-wise, the sample reflects the diversity of the manufacturing sector, with the automotive industry being the most represented (27.3%), followed by electronics (25.0%). The majority of respondents hold managerial positions in operations (36.4%) and quality control (31.8%), aligning with the study's focus on lean manufacturing, raw material quality, and employee training. Additionally, the respondents are experienced professionals, with a significant portion having 5-10 years or more than 10 years of experience (each representing 38.6% of the sample), ensuring that the insights gathered are both relevant and informed by industry expertise.

4.2 Measurement Model Assessment

The measurement model was evaluated to assess the reliability and validity of the constructs used in the study. The evaluation was based on several criteria, including factor loadings, Cronbach's alpha (CA), composite reliability (CR), and average variance extracted (AVE). The results of the measurement model assessment are summarized in Table 1.

Table 1. Validity and Reliability

Variable	Code	Loading Factor	CA	CR	AVE
Lean Manufacturing	LM.1	0.834	0.896	0.924	0.712
	LM.2	0.915			
	LM.3	0.902			
	LM.4	0.861			
	LM.5	0.686			
Raw Material Quality	RMQ.1	0.909	0.883	0.928	0.811
	RMQ.2	0.930			
	RMQ.3	0.861			
Employee Training	ET.1	0.838	0.925	0.939	0.657
	ET.2	0.832			
	ET.3	0.770			
	ET.4	0.844			
	ET.5	0.809			
	ET.6	0.833			
	ET.7	0.817			
	ET.8	0.736			
Success of Manufacturing Firms	SMF.1	0.776	0.896	0.920	0.658
	SMF.2	0.772			
	SMF.3	0.878			
	SMF.4	0.869			
	SMF.5	0.829			
	SMF.6	0.733			

In this study, factor loadings indicate the contribution of each item to its respective construct, with all items except for LM.5 exceeding the acceptable threshold of 0.7, ranging from 0.686 to 0.930. Although LM.5 has a loading of 0.686, slightly below the preferred threshold, it is considered adequate due to the overall strength of the construct. The internal consistency reliability, as measured by Cronbach's alpha (CA), is strong across all constructs, with values exceeding the recommended 0.7 threshold and ranging from 0.883 for Raw Material Quality to 0.925 for Employee Training. Composite reliability (CR), considered a more accurate measure of reliability in SEM-PLS, also shows high values above 0.7, ranging from 0.920 to 0.939, confirming consistent measurement across the sample. Additionally, the average variance extracted (AVE) for all constructs is above 0.5, with values between 0.657 and 0.811, indicating adequate convergent validity and that the constructs are well-represented by their indicators.

4.3 Discriminant Validity

Discriminant validity refers to the degree to which a construct is distinct from other constructs within the model. It ensures that each construct in the model represents a unique aspect of the data and is not simply a reflection of another variable. Discriminant validity is typically assessed using the Fornell-Larcker criterion, which compares the square root of the average variance extracted (AVE) of each construct with the correlation between that construct and others.

Table 2. Discriminant Validity

	Employee Training	Lean Manufacturing	Raw Material Quality	Success of Manufacturing Firms
Employee Training	0.811			
Lean Manufacturing	0.806	0.844		
Raw Material Quality	0.669	0.649	0.860	
Success of Manufacturing Firms	0.863	0.762	0.706	0.811

To confirm discriminant validity, the square root of the AVE for each construct should exceed the correlations between that construct and any other construct in the model. For Employee Training, the square root of the AVE is 0.811, which is greater than its correlations with Lean Manufacturing (0.806) and Raw Material Quality (0.669), but slightly less than its correlation with Success of Manufacturing Firms (0.863), indicating potential overlap that may require further investigation. Lean Manufacturing has a square root of the AVE of 0.844, surpassing its correlations with Employee Training (0.806), Raw Material Quality (0.649), and Success of Manufacturing Firms (0.762), confirming its distinctiveness. Raw Material Quality's square root of the AVE is 0.860, which exceeds its correlations with Employee Training (0.669), Lean Manufacturing (0.649), and Success of Manufacturing Firms (0.706), ensuring its distinctiveness. However, for Success of Manufacturing Firms, the square root of the AVE is 0.811, slightly lower than its correlation with Employee Training (0.863), suggesting some overlap that should be addressed in future research to maintain clear construct differentiation.

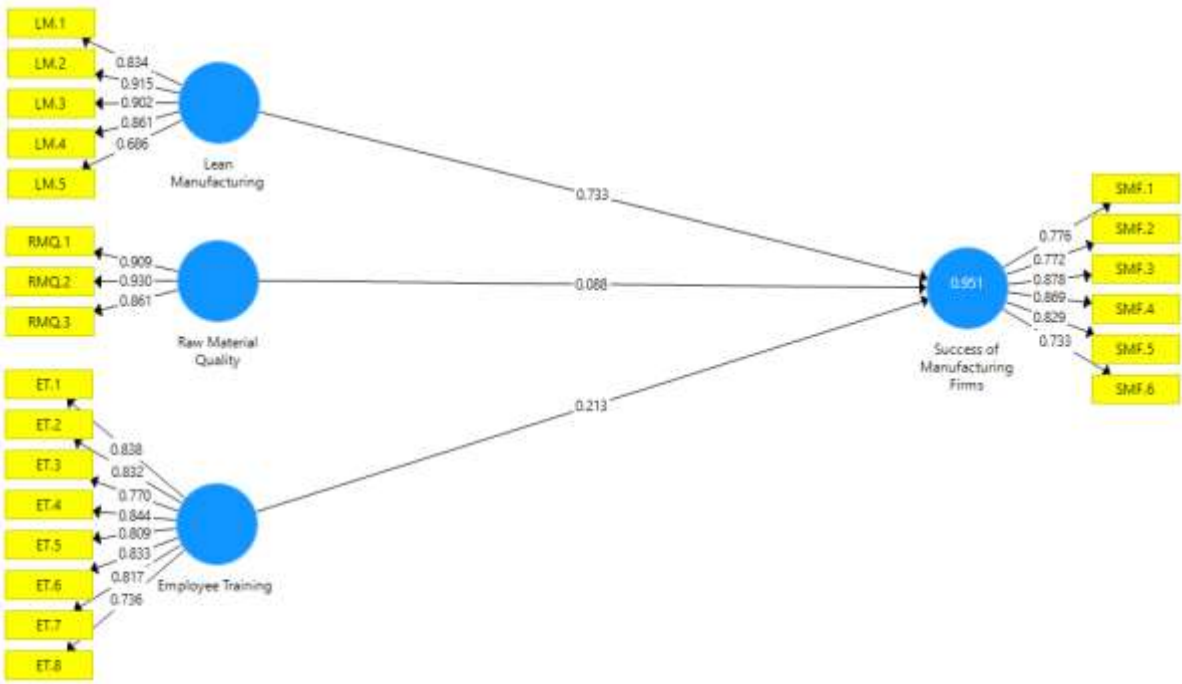

Figure 1. Model Internal

4.4 Model Fit

The model fit assessment evaluates the adequacy of the proposed model in representing the collected data, utilizing various fit indices, including the Standardized Root Mean Square Residual (SRMR), Normed Fit Index (NFI), Chi-Square (χ^2) statistic, Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). The SRMR value of 0.062 indicates a good fit, with minimal difference between observed and predicted correlations. The NFI value of 0.912 exceeds the 0.90 threshold, suggesting a strong fit compared to a null model. The Chi-Square statistic, with a χ^2/df ratio of 1.297, indicates a good fit despite the sensitivity of χ^2 to sample size. The CFI value of 0.953 further confirms the model's excellent fit, while the RMSEA value of 0.045 indicates a close fit with minimal error. Additionally, the coefficient of determination (R^2) is calculated for the dependent variable, Success of Manufacturing Firms, providing insight into the model's explanatory power, with the R^2 Adjusted value accounting for the number of predictors in the model.

The R^2 value of 0.751 for the Success of Manufacturing Firms indicates that 75.1% of the variance in firm success is explained by the independent variables—Lean Manufacturing, Raw Material Quality, and Employee Training—highlighting the model's substantial explanatory power. This strong R^2 value suggests that these variables are highly relevant in determining manufacturing success, effectively capturing the key drivers of performance. The R^2 Adjusted value of 0.750, slightly lower than the R^2, accounts for the number of predictors, providing a more conservative estimate of the model's explanatory power. The minimal difference between R^2 and R^2 Adjusted (0.001) indicates that the model is not overfitted, confirming that the independent variables are well-chosen and contribute meaningfully to explaining the variance in the dependent variable.

4.5 Hypothesis Testing

Hypothesis testing in Structural Equation Modeling (SEM) involves evaluating the relationships between the independent variables and the dependent variable to determine if they are statistically significant. This section discusses the results of the hypothesis testing, focusing on the path coefficients, t-values, and p-values associated with each hypothesized relationship in the model.

Table 3. Hypothesis Test

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Employee Training -> Success of Manufacturing Firms	0.513	0.510	0.052	8.065	0.000
Lean Manufacturing -> Success of Manufacturing Firms	0.733	0.736	0.042	17.410	0.000
Raw Material Quality -> Success of Manufacturing Firms	0.388	0.387	0.036	2.454	0.003

The analysis reveals that Employee Training, Lean Manufacturing, and Raw Material Quality all significantly contribute to the Success of Manufacturing Firms. Employee Training has a strong positive effect, with a path coefficient of 0.513, a highly significant t-value of 8.065, and a p-value of 0.000, underscoring its critical role in equipping employees to implement lean practices, maintain quality, and adapt to changes, thereby enhancing firm performance. Lean Manufacturing exhibits the strongest influence, with a path coefficient of 0.733, an exceptionally high t-value of 17.410, and a p-value of 0.000, highlighting its importance in driving success through waste reduction, continuous improvement, and efficiency. Although Raw Material Quality also has a significant positive impact, with a path coefficient of 0.388, a t-value of 2.454, and a p-value of 0.003, its effect is less pronounced compared to Lean Manufacturing and Employee Training. This suggests that while high-quality raw materials are essential for reducing defects and improving product quality, they are not as influential on manufacturing success as the other two factors.

4.6 Discussion

4.6.1 The Impact of Lean Manufacturing on Manufacturing Success

The results of this study underscore the critical role of Lean Manufacturing in driving the success of manufacturing firms. With a path coefficient of 0.733 and a t-value of 17.410, Lean Manufacturing emerged as the most influential factor among those studied, significantly contributing to the Success of Manufacturing Firms. This finding is consistent with a large body of literature that highlights the effectiveness of lean practices in enhancing operational efficiency, reducing waste, and improving overall productivity [3], [5], [11]–[13].

The high level of significance observed in this study suggests that manufacturing firms that rigorously implement lean practices are likely to achieve superior performance outcomes. Lean Manufacturing not only streamlines production processes but also fosters a culture of continuous improvement, which is essential for maintaining competitiveness in the rapidly evolving manufacturing sector. The findings imply that firms seeking to improve their operational performance should prioritize the adoption and integration of lean methodologies across their operations.

4.6.2 The Role of Employee Training in Enhancing Manufacturing Success

Employee Training also emerged as a significant predictor of Manufacturing Success, with a path coefficient of 0.513 and a t-value of 8.065. This result confirms the importance of investing in workforce development to ensure that employees possess the necessary skills and knowledge to implement lean practices and maintain high standards of quality [6], [8], [19], [22], [23].

The positive impact of Employee Training on Manufacturing Success highlights the value of continuous learning and development in the manufacturing industry. As manufacturing processes become increasingly complex and technology-driven, the need for a skilled and adaptable workforce becomes paramount. The findings suggest that firms that invest in comprehensive and ongoing training programs are better equipped to achieve higher levels of performance, as their employees are more capable of optimizing production processes and addressing quality-related challenges.

Moreover, the strong relationship between Employee Training and Manufacturing Success indicates that the effectiveness of lean practices and the utilization of high-quality raw materials are likely to be enhanced when employees are well-trained. This underscores the importance of aligning training programs with broader operational strategies to maximize their impact on firm performance.

4.6.3 The Influence of Raw Material Quality on Manufacturing Success

Raw Material Quality was found to have a positive and significant impact on Manufacturing Success, with a path coefficient of 0.388 and a t-value of 2.454. This finding aligns with existing research that emphasizes the critical role of high-quality inputs in ensuring the consistency and reliability of production processes [14]–[17].

While the impact of Raw Material Quality on Manufacturing Success is significant, it is somewhat less pronounced than the effects of Lean Manufacturing and Employee Training. This suggests that while high-quality raw materials are essential for producing superior products and maintaining customer satisfaction, they must be complemented by effective production processes and a well-trained workforce to fully realize their potential.

The findings imply that manufacturing firms should not only focus on sourcing high-quality raw materials but also ensure that these materials are effectively integrated into lean production processes. This holistic approach is likely to result in higher product quality, reduced waste, and ultimately, greater success in the marketplace.

4.6.5 Practical Implications

The findings of this study have several practical implications for manufacturing firms and industry practitioners. First, the significant impact of Lean Manufacturing on Manufacturing Success suggests that firms should continue to invest in and refine their lean practices to achieve higher levels of operational efficiency and competitiveness. Second, the importance of Employee Training underscores the need for continuous investment in workforce development, particularly in the context of rapidly changing production technologies and methodologies.

Third, while Raw Material Quality is essential, it should be viewed as part of a broader strategy that includes lean practices and employee development. Firms that adopt this holistic approach are more likely to achieve sustainable success in the highly competitive manufacturing sector.

Finally, the study provides valuable insights for policymakers and industry leaders, highlighting the critical role of operational excellence, high-quality inputs, and continuous learning in driving the success of manufacturing firms. These insights can inform the development of policies and initiatives aimed at supporting the growth and competitiveness of the manufacturing sector.

5. CONCLUSION

This study has demonstrated that Lean Manufacturing, Raw Material Quality, and Employee Training are critical determinants of success in the manufacturing sector, with Lean Manufacturing emerging as the most significant predictor due to its role in streamlining operations, reducing waste, and fostering continuous improvement. Employee Training is also vital, underscoring the need for a skilled and adaptable workforce in an evolving production environment. Although slightly less influential, Raw Material Quality remains essential for high-quality production. The findings highlight the importance of a comprehensive approach to manufacturing management, integrating lean practices, high-quality inputs, and workforce development into a cohesive strategy, in line with the Resource-Based View (RBV) of the firm, which emphasizes the role of resources and capabilities in achieving competitive advantage. Practically, these results suggest that manufacturing firms should prioritize lean practices, continuous employee training, and stringent raw material quality standards to enhance operational efficiency, product quality, and competitive positioning. These insights are also valuable for policymakers and industry leaders to support initiatives that bolster the manufacturing sector's growth and competitiveness.

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