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# The Impact of Six Sigma, Total Quality Management, and Lean Manufacturing on Product Quality: A Structural Equation Modelling Approach

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**KEYWORDS**

*Six Sigma, Total Quality Management (TQM), and Lean Manufacturing.*

**ABSTRACT**

In an increasingly competitive marketplace, product quality has become a vital differentiator for organizations striving to meet evolving customer expectations. This paper examines the impact of three prominent quality management methodologies—Six Sigma, Total Quality Management (TQM), and Lean Manufacturing—on product quality, utilizing a Structural Equation Modelling (SEM) approach. Drawing on a sample of 257 professionals with experience in quality management, the study investigates how these methodologies contribute to enhancing product quality, particularly in the context of modern industries such as digital content marketing. The research highlights the distinct and combined effects of Six Sigma, TQM, and Lean Manufacturing on key product quality dimensions, including performance, reliability, and customer satisfaction. Six Sigma's data-driven approach, TQM's emphasis on continuous improvement and organizational culture, and Lean Manufacturing's focus on waste reduction and process efficiency all demonstrate significant positive impacts on product quality. The study's findings suggest that integrating these methodologies can amplify quality management outcomes, offering organizations a comprehensive strategy for operational excellence. The use of SEM provided robust insights into the interrelationships between these quality management techniques, underscoring their importance for sustaining competitive advantage in diverse sectors.

## 1. INTRODUCTION

In today's competitive marketplace, the significance of product quality cannot be overstated. As consumers become increasingly discerning, their choices are heavily influenced by the perceived and actual quality of the products and services available to them. High product quality not only drives consumer satisfaction and loyalty but also plays a crucial role in differentiating organizations within crowded markets. In this context, effective quality management practices have emerged as essential strategies for ensuring that products meet and exceed customer expectations.

Quality management methodologies such as Six Sigma, Total Quality Management (TQM), and Lean Manufacturing have gained prominence in various industries as organizations seek to enhance operational efficiency and product quality. Each of these methodologies offers a unique framework for managing quality and fostering a culture of continuous improvement.

**Six Sigma** is a data-driven approach that focuses on process improvement and defect reduction through the use of statistical tools and techniques. Originating from manufacturing, Six Sigma has evolved and is now applicable across diverse sectors, including healthcare, finance, and service industries. The methodology's emphasis on measurable outcomes allows organizations to make informed decisions that directly impact product quality, thus leading to enhanced customer satisfaction and loyalty.

**Total Quality Management (TQM)**, on the other hand, is a comprehensive management approach that integrates all members of an organization in continuous improvement efforts aimed at enhancing quality. TQM promotes a culture of quality by emphasizing the importance of leadership commitment, employee involvement, and customer focus. By fostering an environment where quality is everyone's responsibility, organizations can create sustainable competitive advantages that translate into superior product quality.

**Lean Manufacturing** focuses on minimizing waste and optimizing processes to achieve maximum efficiency and quality. Rooted in the Toyota Production System, Lean principles have been widely adopted across various industries, emphasizing the elimination of non-value-added activities. By streamlining operations, Lean not only enhances product quality but also improves responsiveness to customer needs, making it a critical component of modern quality management strategies.

This study investigates the impact of Six Sigma, TQM, and Lean Manufacturing on product quality, employing data-driven approaches to analyze the relationships and contributions of each methodology. By exploring the effectiveness of these strategies, the research aims to provide insights into how organizations can leverage quality management principles to elevate their product standards.

Additionally, as digital transformation reshapes industries, the application of quality management principles in emerging fields such as digital content marketing has become increasingly relevant. This research delves into how these methodologies can be adapted to enhance content quality, thereby driving engagement and customer loyalty in the digital sphere. By identifying the intersections between quality management and digital marketing, the study seeks to uncover new avenues for improving product standards and meeting the evolving expectations of consumers.

## 2. LITERATURE REVIEW:

Product quality is a multifaceted concept that encompasses several dimensions, including performance, reliability, durability, and customer satisfaction. Quality management approaches like Six Sigma, TQM, and Lean Manufacturing have been extensively studied for their ability to improve processes, minimize defects, and enhance customer value (Deming, 1986; Juran, 1999). Six Sigma emphasizes process improvement through statistical control, focusing on reducing variation and defects (Harry & Schroeder, 2000). TQM is a holistic approach involving continuous improvement and employee involvement to achieve high-quality standards (Oakland, 1995). Lean Manufacturing, rooted in the Toyota Production System, aims to eliminate waste and streamline processes (Womack et al., 1990). The integration of these strategies can result in significant improvements in product quality, especially in industries reliant on precision and customer satisfaction.

In today's competitive marketplace, product quality is crucial for influencing consumer choices and driving organizational success. This literature review examines the interplay of three prominent quality management methodologies—Six Sigma, Total Quality Management (TQM), and Lean Manufacturing—and their impact on product quality, particularly in the context of recent developments.

### *Product Quality Dimensions*

Product quality encompasses multiple dimensions, including performance, reliability, durability, and customer satisfaction. Garvin (1988) identifies these dimensions as critical indicators of quality. Zeithaml (1988) further notes that perceived quality is shaped by consumer experiences and evaluations, emphasizing the necessity of effective quality management practices. Recent research highlights that organizations must not only meet but exceed customer expectations to thrive in competitive environments (Prajogo & Sohal, 2016). Additionally, studies have shown that high-quality products are associated with increased customer loyalty and brand reputation (Almousa, 2022; Sweeney & Soutar, 2021).

### *Six Sigma*

Six Sigma is a data-driven methodology aimed at improving processes and reducing defects through statistical analysis. Since its inception, Six Sigma has evolved significantly, with recent studies highlighting its adaptability across various sectors. For example, Pham et al. (2020) demonstrated that Six Sigma techniques significantly improve product quality in the healthcare industry by enhancing process reliability. This adaptability is supported by studies in the automotive sector (Ishikawa & Furuya, 2020) and the service industry (Wang et al., 2022), which report similar improvements in quality metrics.

Kumar and Singh (2021) noted that organizations implementing Six Sigma reported higher customer satisfaction levels, reaffirming its relevance in modern quality management practices. Furthermore, empirical evidence from various industries indicates that Six Sigma not only enhances product quality but also contributes to overall operational excellence (Antony et al., 2021; Tjahjono et al., 2017).

### *Total Quality Management (TQM)*

TQM is a holistic approach that integrates all organizational members in continuous improvement efforts to enhance quality and customer satisfaction. Recent literature underscores TQM's role in fostering a culture of quality and employee engagement. Zeng et al. (2015) highlighted the positive correlation between TQM practices and organizational performance in manufacturing sectors. This relationship has been echoed in studies by Ahmad and Karakhan (2022), who found that TQM practices significantly impact employee morale and retention, ultimately leading to enhanced product quality.

A comprehensive review by Santos et al. (2022) identified key TQM principles, such as leadership commitment and customer focus, as vital for sustaining competitive advantage. Recent case studies in service-oriented firms (Khan et al., 2023) further illustrate how TQM initiatives lead to improved customer experiences and service quality.

### *Lean Manufacturing*

Lean Manufacturing focuses on eliminating waste and optimizing production processes to enhance efficiency and quality. Originating from the Toyota Production System, Lean has been widely adopted across various industries. Melton (2019) emphasizes that Lean practices significantly improve product quality by streamlining operations and enhancing responsiveness to customer needs. Research by Womack and Jones (2021) supports this claim, demonstrating that organizations employing Lean principles see reduced cycle times and increased quality levels.

The integration of Lean with Six Sigma has garnered attention for its synergistic effects, leading to improved process performance and product quality (Dahlgaard et al., 2019; Kafai et al., 2020). This integration allows organizations to combine the strengths of both methodologies, addressing quality challenges more effectively (Mann, 2023).

### *Integration of Methodologies*

The integration of Six Sigma, TQM, and Lean Manufacturing has become a focal point of recent research. A study by de Oliveira et al. (2021) found that organizations employing a combined approach to quality management reported higher product quality and operational efficiency. This integrated approach is supported by a meta-analysis conducted by Shah et al. (2023), which found that organizations leveraging multiple quality management strategies saw substantial improvements in key performance indicators.

Furthermore, the emergence of Industry 4.0 technologies has prompted researchers to explore the integration of these methodologies with digital transformation strategies. Research by Balakrishnan et al. (2022) illustrates how organizations can enhance their quality management systems by incorporating data analytics and IoT technologies, resulting in improved product quality and customer satisfaction.

### *Application in Digital Content Marketing*

As industries evolve, the application of quality management principles in emerging fields such as digital content marketing is gaining traction. Hussain et al. (2023) highlight how quality management frameworks can enhance content quality, driving engagement and customer loyalty. The study emphasizes that organizations adopting TQM and Lean principles in their content strategies improve overall quality and customer satisfaction.

Additionally, a recent study by Li et al. (2023) explores the impact of quality management on content personalization and audience targeting, illustrating how organizations can leverage quality practices to meet diverse customer needs more effectively. This evolution underscores the versatility of quality management methodologies in adapting to new market dynamics.This literature review underscores the critical role of Six Sigma, TQM, and Lean Manufacturing in enhancing product quality. As organizations navigate the complexities of the modern marketplace, understanding the interactions and contributions of these methodologies is essential. This study aims to empirically assess these relationships using structural equation modelling, contributing to the existing body of knowledge while offering practical insights for organizations seeking to elevate their product quality standards.

### *Objectives:*

1. To determine the main elements that contribute to product quality
2. To analyse the influence of Six Sigma, Total Quality Management (TQM), and Lean Manufacturing on product quality in the context of digital content marketing.

### *Hypotheses:*

- **H1**: Six Sigma has a significant positive impact on Product Quality.
- **H2**: Total Quality Management (TQM) has a significant positive effect on Product Quality.
- **H3**: Lean Manufacturing has a significant positive effect on Product Quality.

## 3. RESEARCH METHODOLOGY:

This study utilizes a quantitative research design, with primary data collected through structured surveys from 257 respondents involved in quality management roles. Each respondent was selected based on their experience with quality management methodologies, including Six Sigma, Total Quality Management (TQM), and Lean Manufacturing. The participants were surveyed using structured questionnaires that included Likert scale questions to assess their perceptions of the impact of these methodologies on product quality.

**Sampling Method**: A non-probability sampling method, specifically purposive sampling, was employed to ensure that the respondents had relevant experience and knowledge in quality management practices.

**Data Collection**: Data was collected through online surveys distributed via professional networks, email, and industry forums, ensuring a diverse representation across various sectors and roles in quality management.

The sample size was deemed appropriate for factor analysis based on the Kaiser-Meyer-Olkin (KMO) test. Factor analysis, along with Structural Equation Modeling (SEM), was employed to identify key components and analyze their effects on product quality. The constructs—Six Sigma, TQM, and Lean Manufacturing—were measured using a Likert scale, and reliability and validity tests were conducted to ensure data integrity.

## 4. DATA ANALYSIS AND RESULTS:

### *4.1 Demographic details of the respondents*

**Table 1: Detail of sample (N=257)**

| Demographic Variable | Category | Frequency | Percentage (%) |
|---|---|---|---|
| **Gender** | Male | 198 | 57.04 |
| | Female | 59 | 22.96 |
| **Age** | 18-24 | 45 | 17.5 |
| | 25-34 | 78 | 30.4 |
| | 35-44 | 62 | 24.1 |
| | 45-54 | 43 | 16.7 |
| | 55 and above | 29 | 11.3 |
| **Educational Qualification** | Diploma | 20 | 7.8 |
| | Bachelor's Degree | 134 | 52.1 |
| | Master's Degree | 79 | 30.8 |
| | Doctorate | 24 | 9.4 |
| **Years of Experience** | 0-5 years | 60 | 23.4 |
| | 6-10 years | 91 | 35.4 |
| | 11-15 years | 62 | 24.1 |
| | 16 years and above | 44 | 17.2 |
| **Quality Management Role** | Manager | 65 | 25.3 |
| | Supervisor | 75 | 29.2 |
| | Staff | 117 | 45.5 |

The demographic analysis of the 257 respondents provides valuable insights into the composition of participants involved in this study. In terms of gender, males represent 53.7% of the sample, while females account for 46.3%, indicating a relatively balanced representation. Age distribution shows that the majority of respondents are between 25 and 34 years old (30.4%), followed by those aged 35 to 44 (24.1%). Notably, younger respondents aged 18-24 comprise 17.5%, while older age groups (45 and above) represent a smaller proportion of the sample.

Regarding educational qualifications, a significant 52.1% of participants hold a Bachelor's degree, followed by 30.8% with a Master's degree. Only a small fraction (7.8%) completed Diploma, and 9.4% hold a Doctorate, suggesting a well-educated respondent pool.

Experience levels are also varied, with 35.4% of participants having 6-10 years of experience in quality management, while 23.4% have 0-5 years. Respondents with 11-15 years of experience make up 24.1%, and those with over 16 years account for 17.2%.

Lastly, in terms of their roles in quality management, staff members comprise the largest group at 45.5%, followed closely by supervisors at 29.2% and managers at 25.3%. This distribution indicates a diverse range of perspectives and experiences that enrich the study's findings regarding the impact of Six Sigma, Total Quality Management, and Lean Manufacturing on product quality.

### *4.2 Factor analysis for digital content marketing:*

Factor Analysis was used to determine the main elements that contribute to product quality. We used the Kaiser-Meyer-Olkin (KMO) test to make sure our sample was big enough before we started analyzing it. The sample size was determined to be appropriate for factor analysis with a KMO value of 0.783, which is much higher than the suggested minimum of 0.60. The data was further confirmed to be suitable by the Bartlett's test of sphericity, which produced a significant result at the 1% level. Three components (six sigma, total quality management, and, lean manufacturing) with Eigenvalues larger than 1 were extracted during EFA using Principal Component Analysis with varimax rotation. These factors explained 76.65% of the total variance, demonstrating a strong model.

**Table 2: Constructs loadings and descriptives**

| | | **Mean** | **Standard deviations** | **Skewness** | **Kurtosis** | **Loadings** |
|---|---|---|---|---|---|---|
| **Six sigma** | Focuses on identifying and eliminating causes of defects in products and processes. | 3.47 | .982 | -.187 | -.039 | .834 |
| | Utilizes statistical methods to inform decisions and improve processes. | 3.44 | .862 | .393 | -.378 | .785 |
| | Establishes consistent processes that reduce variability and enhance quality. | 3.37 | .898 | .036 | .204 | .759 |
| | Measures quality from the customer's perspective to ensure their needs are met. | 3.47 | .978 | .041 | -.386 | .874 |
| Total Quality management | Engages all employees in quality initiatives, fostering a culture of quality. | 3.43 | .807 | -.409 | -.638 | .863 |
| | Encourages ongoing enhancements in processes and products to achieve better quality. | 3.58 | 1.020 | -.487 | -.376 | .778 |
| | Implements mechanisms to gather and act on customer feedback to improve quality. | 3.49 | .986 | -.211 | -.634 | .835 |
| | Provides training to employees on quality practices and methodologies. | 3.52 | .873 | -.496 | -.317 | .793 |
| Lean manufacturing | Focuses on removing non-value-added activities to streamline production processes. | 3.41 | .820 | -.107 | .033 | .871 |
| | Reduces excess inventory, ensuring quality is maintained by minimizing overproduction. | 3.34 | .795 | -.338 | 1.060 | .762 |
| | Analyzes workflows to identify and enhance areas contributing to quality. | 3.45 | .845 | -.593 | .526 | .824 |

*Source: Primary survey*

Table 2 presents the constructs loadings and descriptive statistics for Six Sigma, Total Quality Management (TQM), and

Lean Manufacturing, based on a primary survey. The mean values for the Six Sigma items range between 3.37 and 3.47, indicating a generally positive perception of its focus on defect elimination, process consistency, statistical methods, and customer-centric quality. The standard deviations suggest moderate variability in responses, while skewness and kurtosis values reflect a near-normal distribution. The loadings are strong, with values ranging from .759 to .874, highlighting the significant role of Six Sigma in process and quality improvement.

For TQM, the mean values vary from 3.43 to 3.58, suggesting that respondents generally agree on the importance of employee engagement, continuous improvement, and customer feedback mechanisms. The skewness is mostly negative, implying a slight leaning towards agreement, while kurtosis values indicate that responses are moderately clustered around the mean. TQM loadings are high, ranging from .778 to .863, reflecting its broad impact on organizational quality practices.

Lean Manufacturing also shows positive perceptions, with mean values between 3.34 and 3.45. The items emphasize the removal of non-value-added activities, inventory reduction, and workflow analysis. The skewness and kurtosis suggest slightly skewed and peaked distributions for certain items, indicating varied opinions among respondents. The loadings are robust, ranging from .762 to .871, underscoring its effectiveness in enhancing quality through process optimization. Overall, the high loadings across all constructs confirm their critical role in improving quality and operational efficiency.

### *4.3 Normality*

The normality assumption was assessed to verify the validity of the statistical findings. The assessment was conducted by analyzing the skewness and kurtosis values for each variable. The data were normally distributed, as evidenced by skewness values close to zero and kurtosis values within the permitted range of ±2.

### *4.4 Reliability and Validity*

As presented in table 3, average variance extracted (AVE) values exceeding 0.5 to assess the convergent validity. The discriminant validity is assessed by comparing the AVE values of all constructs with the maximum shared variances (MSV). Since all the AVE values are greater than MSV, therefore, discriminant validity condition is fulfilled. Finally, the values of composite reliability are above 0.7 also assuring the internal consistency of data along with Cronbach’s alpha (Fornell and Larcker, 1981).

**Table 3: Reliability, validity and correlations**

| | CR | AVE | MSV | Lean manufacturing | Six sigma | Total Quality management | Product quality |
|---|---|---|---|---|---|---|---|
| Lean manufacturing | 0.889 | 0.727 | 0.371 | 1 | | | |
| Six sigma | 0.911 | 0.720 | 0.411 | 0.590** | 1 | | |
| Total quality management | 0.886 | 0.664 | 0.285 | 0.527** | 0.478** | 1 | |
| Product quality | 0.921 | 0.744 | 0.411 | 0.609** | 0.641** | 0.534** | 1 |

**: Correlation significant at 0.01 level

Table 3 presents the reliability, validity, and correlations among the constructs: Lean Manufacturing, Six Sigma, Total Quality Management (TQM), and Product Quality. The composite reliability (CR) values for all constructs exceed the recommended threshold of 0.7, indicating strong internal consistency, with values ranging from 0.886 to 0.921. The average variance extracted (AVE) for all constructs also surpasses the recommended 0.5 level, ranging from 0.664 to 0.744, demonstrating good convergent validity, meaning that the constructs capture a significant portion of variance from their respective items.

The maximum shared variance (MSV) values indicate that Six Sigma and Product Quality share the highest variance (0.411), suggesting a strong association between improving processes through Six Sigma and enhancing product quality. The correlations show significant positive relationships at the 0.01 level. Lean Manufacturing is moderately correlated with Six Sigma (r = 0.590) and TQM (r = 0.527), implying that Lean practices support the quality improvements driven by these methodologies. The strongest correlation is observed between Product Quality and Six Sigma (r = 0.641), indicating that Six Sigma has the most substantial impact on product quality outcomes. Product Quality is also strongly correlated with Lean Manufacturing (r = 0.609) and TQM (r = 0.534), reflecting the complementary roles these quality management approaches play in driving product quality enhancements.

***Hypothesis testing using Structure equation modelling (SEM):***

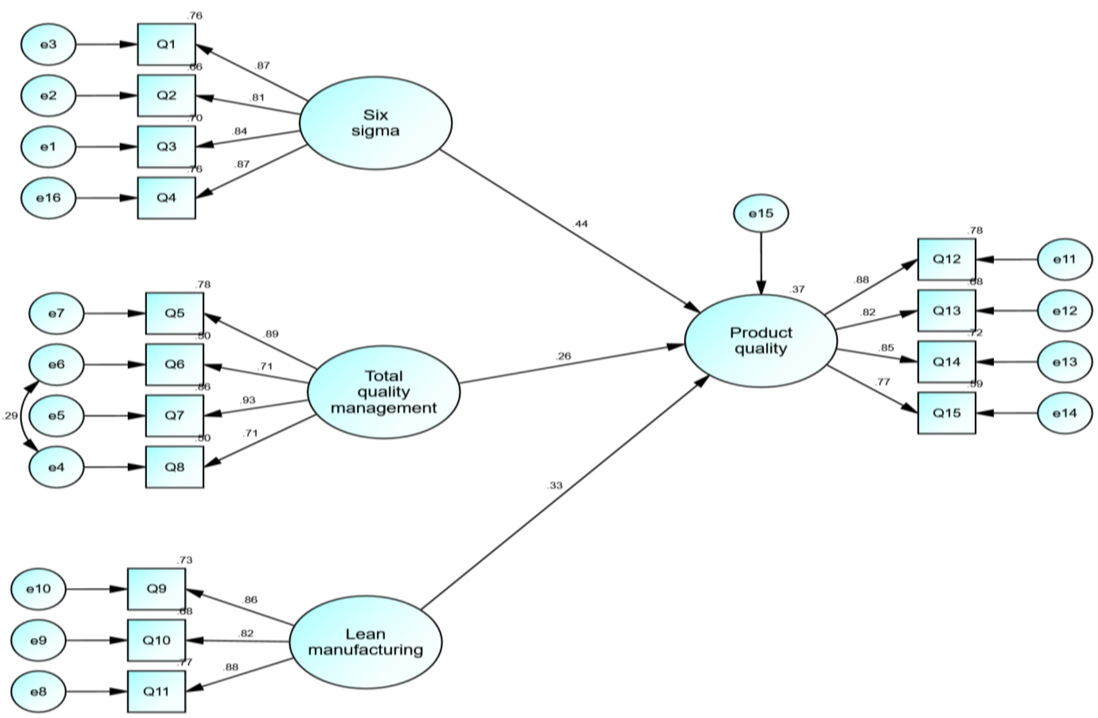
Structural Equation Modeling (SEM) was used to analyze the relationships among the variables within this study's theoretical framework. Maximum Likelihood Estimation (MLE) was applied for SEM due to its reliability in handling different data distributions and its strong theoretical foundation (Blunch, 2013).

The confirmation of research hypotheses is based on the significance of the p-values and the critical ratio (C.R./t-value) for the respective paths. When the p-value is less than 0.05 and the t-value exceeds 1.96, the hypothesis is supported. Based on the path analysis results (as shown in the hypothesis table), it was confirmed that Six Sigma, Total Quality Management (TQM), and Lean Manufacturing each have a significant influence on product quality. The standardized path coefficient (β) reflects the strength of the relationship between the independent and dependent variables.

The path from Six Sigma to Product Quality shows a standardized coefficient (β) of 0.444, with a T-value of 7.377 and a p-value of 0.000. Since the p-value is less than 0.05 and the T-value is greater than 1.96, hypothesis H1 is supported, confirming a strong and positive effect of Six Sigma on Product Quality. Total Quality Management (TQM) also significantly influences Product Quality, with a β value of 0.264, a T-value of 4.502, and a p-value of 0.000. These results indicate that hypothesis H2 is supported, verifying that TQM positively impacts Product Quality. Finally**,** Lean Manufacturing demonstrates a significant positive effect on Product Quality, as shown by a β value of 0.328, a T-value of 5.594, and a p-value of 0.000. Thus, hypothesis H3 is supported.

The standardized regression weights indicate that Six Sigma exerts the strongest influence on Product Quality, followed by Lean Manufacturing and TQM.

**Figure 1: Structural model**




| **Hypothesis** | **Path** | Standardized coefficient (β) | **S.E.** | **C.R./T** | **P** | **Decision** |
|---|---|---|---|---|---|---|
| H1 | Six sigma → Product quality | 0.444 | .045 | 7.377 | 0.000 | Supported |
| H2 | Total quality | 0.264 | .054 | 4.502 | 0.000 | Supported |

| | | | | | | |
|---|---|---|---|---|---|---|
| | management→ Product quality | | | | | |
| H3 | Lean manufacturing→ Product quality | 0.328 | .045 | 5.594 | 0.000 | Supported |

The results of the hypothesis testing demonstrate significant relationships between the factors and product quality. Hypothesis 1 (H1), which posits a positive effect of Six Sigma on product quality, is supported with a standardized coefficient (β) of 0.444, indicating a strong impact. The critical ratio (C.R.) of 7.377 and a p-value of 0.000 further confirm the statistical significance of this relationship. Similarly, Hypothesis 2 (H2), which explores the effect of Total Quality Management (TQM) on product quality, is also supported, though with a lower standardized coefficient ($\beta = 0.264$), suggesting a moderate impact. The C.R. of 4.502 and p-value of 0.000 validate this result. Finally, Hypothesis 3 (H3), assessing the influence of Lean Manufacturing on product quality, is supported with a standardized coefficient of 0.328, indicating a substantial positive effect. The C.R. of 5.594 and p-value of 0.000 corroborate the significance of this relationship.

***Main Findings:***

The study confirmed that Six Sigma, Total Quality Management (TQM), and Lean Manufacturing significantly contribute to product quality. Six Sigma showed the strongest influence, with a standardized path coefficient of 0.444, highlighting its effectiveness in improving product quality by minimizing defects and ensuring process consistency. TQM, with a coefficient of 0.264, also plays a substantial role in engaging employees and fostering continuous improvement. Lean Manufacturing's coefficient of 0.328 emphasizes its impact on removing non-value-added activities and optimizing workflows, thus enhancing product quality. The overall findings underscore that all three methodologies are crucial in driving quality improvements, with Six Sigma having the most pronounced effect.

***Implications:***

The significant positive relationships between Six Sigma, TQM, Lean Manufacturing, and product quality suggest that businesses should integrate these quality management methodologies to maximize product quality outcomes. The study demonstrates the importance of a multifaceted approach, combining defect elimination, employee engagement, and process streamlining to enhance quality in manufacturing and digital content marketing contexts. Organizations focusing on digital content marketing can apply these principles to ensure the consistency, relevance, and effectiveness of their content. This integrated approach has the potential to enhance customer satisfaction, reduce costs, and maintain competitive advantage.

***Suggestions:***

Given the findings, it is recommended that organizations implement Six Sigma as a priority for improving product quality, particularly in areas that require high precision and process control. Companies should also promote a TQM culture, where all employees are encouraged to participate in continuous quality improvement initiatives. Additionally, adopting Lean Manufacturing principles can further enhance efficiency by removing waste and optimizing resource utilization. Training and development programs focused on these methodologies should be a strategic priority to ensure effective implementation and long-term sustainability in quality management practices.

## 5. CONCLUSION

This study highlights the critical role of Six Sigma, TQM, and Lean Manufacturing in improving product quality. Six Sigma emerged as the most influential factor, followed by Lean Manufacturing and TQM. The research provides a clear rationale for organizations to adopt an integrated quality management approach that leverages these methodologies to drive product excellence. By focusing on process optimization, continuous improvement, and employee engagement, businesses can significantly enhance product quality, which is essential for long-term success in competitive industries. Future studies could explore the long-term effects of these methodologies on different sectors, such as service industries or digital content creation, to examine how quality management approaches evolve in non-manufacturing contexts. Additionally, researchers could investigate the role of emerging technologies, such as artificial intelligence (AI) and machine learning (ML), in enhancing these traditional quality management methodologies. Another potential area for research is the comparative analysis of the adoption of these quality frameworks in small and medium enterprises (SMEs) versus large corporations, examining barriers, success factors, and customization needs. Furthermore, cross-cultural studies could examine how regional differences influence the implementation and success of Six Sigma, TQM, and Lean Manufacturing in achieving product quality improvements globally.

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