

The Impact of Total Quality Management with an Emphasis on Customer Orientation and Continuous Improvement on the Competitiveness of Nanotechnology Industries (A Case Study of Small and Medium-Sized Enterprises (SMEs))

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ABSTRACT

The purpose of this study was to investigate the relationship between Total Quality Management (TQM) practices and the competitiveness of nanotechnology industries. Using Structural Equation Modeling (SEM), the study examined the causal relationships among Total Quality Management, customer orientation, continuous improvement, and competitiveness. The statistical population consisted of all manufacturing and service companies operating in the field of designing, producing, and distributing textile products across the country. The sample size was determined using Cochran's formula and a simple random sampling method. A total of 500 questionnaires were distributed, and after excluding incomplete responses, data from 185 companies were analyzed, indicating a high level of reliability of the findings at the company level. Total Quality Management (TQM), based on the models proposed by Suciati et al. (2024) and Sun et al. (2022), was measured across five main dimensions, including leadership and top management support, employee training and participation, information and learning, process management, and customer focus, through 21 indicators. TQM performance from the perspective of customer orientation and continuous improvement was assessed using the models of Permana et al. (2019) and Megirang et al. (2023) through 10 indicators. Competitiveness was measured using the questionnaires developed by Perez-Brito and Bojorquez Zapata (2017) and Kafetzopoulos et al. (2015), across two dimensions of domestic and international competitiveness through 14 indicators. The reliability of the instrument was evaluated using Cronbach's alpha coefficient, and the results confirmed the acceptable reliability of the questionnaire. Responses for all variables were recorded using a five-point Likert scale. The complex relationships among latent variables and the hypothesis testing process were analyzed using the advanced statistical technique of Structural Equation Modeling (SEM) to accurately examine both direct and indirect effects of the factors. The results indicated that all hypotheses exhibited positive and significant relationships. Customer orientation, continuous improvement, and competitiveness independently affected Total Quality Management. The strongest relationship was related to the effect of continuous improvement (0.46), while the weakest relationship was associated with the effect of competitiveness (0.34) on Total Quality Management. Furthermore, competitiveness, as the core variable, had a direct effect on customer orientation and continuous improvement. The findings suggest that integrating quality principles can contribute to operational excellence, process innovation, and sustainable growth in fields where product precision and reliability are critical.

Keywords: Total Quality Management, Customer Orientation, Continuous Improvement, Competitiveness, Nanotechnology Industries.



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Introduction

Total Quality Management (TQM) has become one of the most influential managerial approaches for organizations seeking to strengthen operational performance, customer responsiveness, innovation capacity, and sustainable competitiveness. In contemporary business environments, firms are increasingly required to compete not only through cost efficiency and product availability, but also through quality consistency, process reliability, technological adaptability, and responsiveness to rapidly changing customer expectations. TQM provides an integrated managerial philosophy through which organizations can align leadership commitment, employee involvement, process control, customer orientation, continuous improvement, and data-based decision-making to enhance organizational outcomes (1, 2). Recent evidence shows that TQM is no longer limited to traditional manufacturing settings but has expanded into education, services, banking, cooperatives, insurance, and technology-intensive industries, indicating its broad applicability as a strategic quality framework (3-7). This expansion demonstrates that quality management is now regarded as a core organizational capability rather than a narrow operational technique.

The relevance of TQM has become even more pronounced in industries characterized by technological complexity and rapid innovation cycles. Nanotechnology industries, particularly small and medium-sized enterprises (SMEs), operate in highly uncertain markets where precision, reliability, standardization, and product performance are central to survival and growth. These firms must transform scientific knowledge into scalable products while meeting strict technical requirements and customer expectations. The commercialization of nanotechnology innovations requires bridging the gap between laboratory-based invention and marketable production, a process that depends heavily on quality assurance, process control, and organizational learning (8). SMEs in high-technology sectors often possess agility and flexibility, yet they face limitations in financial resources, managerial capabilities, and access to advanced infrastructure (9). Therefore, for nanotechnology SMEs, TQM can function as a managerial architecture that supports the systematic integration of quality, innovation, and competitiveness.

A central premise of TQM is that quality improvement must be embedded in all organizational processes rather than assigned to a single department. Studies on TQM implementation have emphasized the importance of leadership support, employee participation, customer focus, training, process management, information systems, and continuous improvement as key pillars of successful quality management (10-12). Leadership commitment is particularly critical because it shapes the organizational culture necessary for sustained quality practices. Without senior management support, quality initiatives often remain symbolic and fail to influence operational routines. Similarly, employee participation allows quality improvement to become a shared organizational responsibility, enabling workers to identify defects, propose process improvements, and contribute to performance enhancement (13, 14). In technology-driven sectors such as nanotechnology, where minor process deviations may produce major performance differences, the integration of managerial commitment and employee engagement becomes essential.

Customer orientation is another fundamental dimension of TQM and is especially important in competitive and knowledge-intensive markets. Customer-oriented organizations systematically identify customer needs, translate them into product and service specifications, and continuously evaluate customer satisfaction as a guide for improvement. TQM is strongly associated with customer satisfaction because quality practices improve responsiveness, consistency, and reliability in service and product delivery (15, 16). In industries where customers may include research institutions, industrial buyers, governmental bodies, and advanced manufacturing companies,

customer requirements are often complex and technically specific. Therefore, customer orientation enables firms to align their innovation outputs with market demand and reduce the risk of producing technologically advanced but commercially weak products. Marketing research also shows that customer orientation and competitor orientation jointly influence market performance, indicating that competitiveness depends on understanding both customer needs and rival behavior (17).

Continuous improvement represents the dynamic component of TQM and is closely connected to organizational learning, innovation, and process excellence. In fast-evolving technological fields, continuous improvement cycles help organizations refine processes, reduce waste, improve product reliability, and respond to technological changes (18). Empirical reviews have emphasized that continuous improvement is directly related to process performance and organizational effectiveness because it encourages systematic problem-solving and incremental innovation (19). Manufacturing studies further indicate that continuous improvement behaviors are strengthened when organizations institutionalize quality standards and create mechanisms for ongoing evaluation and correction (20). In nanotechnology industries, continuous improvement is not merely a managerial preference; it is a technical necessity because product accuracy, safety, reproducibility, and scalability require constant refinement of production and quality-control processes.

The relationship between TQM and innovation is particularly relevant for nanotechnology SMEs. Quality management and innovation were previously viewed by some scholars as separate or even conflicting priorities, with quality emphasizing standardization and innovation emphasizing flexibility. However, recent studies suggest that TQM can enhance innovation by creating disciplined processes for knowledge sharing, problem-solving, and customer-driven development (21, 22). A knowledge management and organizational agility perspective also indicates that successful TQM implementation depends on the organization's ability to capture, distribute, and apply knowledge effectively (23). In this regard, TQM can support both exploitative innovation, through process refinement and defect reduction, and exploratory innovation, through customer feedback, cross-functional learning, and continuous improvement. For nanotechnology firms, this dual role is valuable because they must simultaneously maintain strict quality standards and pursue technological advancement.

The emergence of Quality 4.0 has further expanded the strategic relevance of TQM by integrating digital technologies, data analytics, automation, and smart production systems into quality management practices. Quality 4.0 links traditional quality principles with Industry 4.0 technologies and enables firms to improve decision-making, predictive control, real-time monitoring, and process optimization (24). For SMEs operating in advanced technological industries, the integration of digital tools with TQM can improve transparency, reduce process variability, and accelerate innovation. Lean manufacturing and lean accounting studies similarly show that process efficiency, waste reduction, and performance measurement systems contribute to organizational performance by aligning operational decisions with strategic objectives (25, 26). These developments indicate that quality management has evolved from a compliance-oriented system into a strategic platform for operational intelligence and competitiveness.

Competitiveness is a multidimensional construct that reflects a firm's ability to maintain and improve its market position relative to competitors. In SMEs, competitiveness depends on strategic orientation, innovation capabilities, resource utilization, adaptability, access to finance, and environmental responsiveness (27, 28). Dynamic capabilities are especially important because SMEs must reconfigure resources in response to market turbulence and technological disruption (28). Access to finance also plays a critical role in supporting innovation, technology

adoption, and competitive expansion, particularly for firms in capital-intensive sectors (29). Because nanotechnology SMEs often require specialized equipment, skilled personnel, and research-based development, their competitiveness cannot be separated from their ability to combine quality management with innovation capacity and strategic resource deployment.

Several studies have confirmed that TQM contributes positively to organizational performance and competitive advantage. TQM practices enhance company performance through human resource management, employee motivation, innovation strategy, and operational discipline (30-32). Evidence from SMEs also suggests that TQM can improve organizational performance through the mediating role of competitive advantage, showing that quality management generates value when it is translated into market-relevant capabilities (33). Meta-analytic evidence further supports TQM as a sustained competitive strategy, suggesting that quality management has cumulative effects on performance when consistently implemented across organizational systems (34). These findings are important for nanotechnology SMEs because they imply that TQM should be treated not as a short-term improvement program but as a long-term strategic capability.

The COVID-19 pandemic and subsequent market disruptions have also highlighted the importance of quality management and competitiveness in uncertain environments. Firms faced supply-chain instability, changing customer demand, and operational restrictions, making adaptability and process resilience crucial for survival. Research on SMEs during the pandemic showed that government policy, business strategy, and organizational adaptation significantly shaped firm resilience (35). Similarly, managerial recommendations based on TQM during the pandemic emphasized that firms can improve competitive capability by strengthening process quality, customer responsiveness, and continuous improvement mechanisms (12). These insights are relevant beyond crisis conditions because they show that TQM can support resilience in volatile markets. For nanotechnology SMEs, which already operate under technological and market uncertainty, quality management may help reduce operational risk and improve strategic stability.

Internationalization and market expansion add another layer of complexity to competitiveness. Firms seeking to enter or expand in international markets must integrate strategy, capabilities, environmental awareness, and sustainable drivers of performance (36). For nanotechnology SMEs, international competitiveness requires compliance with global standards, reliable product quality, technical certification, and the ability to satisfy sophisticated customers. Strategic improvisation and corporate entrepreneurship may also influence SME performance when firms operate in uncertain competitive contexts (37). TQM can support these capabilities by establishing standardized processes, improving knowledge flows, and strengthening customer trust. At the same time, quality management must be flexible enough to support innovation, customization, and rapid response to international market opportunities.

Operational performance is another key mechanism through which TQM can influence competitiveness. Studies in manufacturing contexts show that efforts to improve operational performance depend on process analysis, production control, and systematic improvement practices (38). Productivity and efficiency are enhanced when TQM is deployed as a comprehensive organizational approach rather than a fragmented set of tools (39). The integration of quality systems, such as Six Sigma and ISO 9001, further demonstrates that structured quality methods can improve product quality and production processes (40). These findings are highly relevant for nanotechnology industries because operational errors at the nanoscale may compromise product reliability, customer confidence,

and market acceptance. Therefore, competitiveness in this field depends on both technical innovation and operational excellence.

Despite the growing literature on TQM, customer orientation, continuous improvement, and competitiveness, several gaps remain. First, much of the available research has focused on conventional manufacturing, services, education, banking, and general SMEs, while comparatively less attention has been paid to nanotechnology industries as knowledge-intensive and precision-dependent sectors (5-7). Second, although many studies have examined the direct relationship between TQM and performance, fewer have simultaneously considered the roles of customer orientation and continuous improvement in explaining competitiveness (15, 19). Third, the strategic conditions of SMEs require special attention because these firms often combine agility with resource constraints, making the successful implementation of TQM both necessary and challenging (9, 28). Addressing these gaps can contribute to a more precise understanding of how quality management supports competitiveness in emerging technology sectors.

In addition, the multidimensional nature of TQM requires empirical models capable of analyzing complex causal relationships among latent constructs. Structural Equation Modeling is particularly suitable for examining such relationships because it allows researchers to test direct and indirect effects among quality management, customer orientation, continuous improvement, and competitiveness. Prior studies have emphasized that organizational performance emerges from the interaction of managerial systems, strategic orientation, capabilities, and environmental factors rather than from isolated practices (27, 36). Accordingly, examining TQM in relation to customer orientation and continuous improvement can offer a more comprehensive explanation of how firms enhance competitiveness. This is particularly important in nanotechnology SMEs, where organizational performance depends on combining scientific capability, market responsiveness, operational accuracy, and strategic flexibility.

Overall, the literature suggests that TQM provides a strategic foundation for improving competitiveness by strengthening quality culture, customer responsiveness, process discipline, employee involvement, innovation capacity, and continuous improvement. Customer orientation enables firms to align technological capabilities with market expectations, while continuous improvement supports ongoing process refinement, error reduction, and adaptability. In nanotechnology industries, these mechanisms are especially important because firms operate under conditions of technological complexity, high precision requirements, market uncertainty, and intense competition. Although prior studies have examined various dimensions of TQM and competitiveness across different sectors, there remains a need for integrated research that specifically analyzes the relationships among TQM, customer orientation, continuous improvement, and competitiveness in nanotechnology SMEs.

The aim of this study is to investigate the impact of Total Quality Management on the competitiveness of nanotechnology SMEs, with particular emphasis on the roles of customer orientation and continuous improvement.

Methods and Materials

In terms of purpose, the present study is categorized as an applied research study, since its findings can be directly utilized to improve quality management processes and competitiveness within the textile industry. In terms of nature, this research is descriptive-survey research, specifically aimed at identifying and analyzing the relationships among various variables such as Total Quality Management (TQM), competitiveness, and customer orientation in companies operating within the textile industry. Descriptive studies generally focus on examining the

existing conditions and specific characteristics of a phenomenon or issue, whereas survey studies seek to collect data and information from selected samples of the statistical population through instruments such as questionnaires or interviews. Accordingly, the present study investigates the impact of Total Quality Management on competitiveness in the textile industry through the application of a survey research method.

The statistical population of the study consisted of all companies operating in the national textile industry. More specifically, this population included manufacturing and service companies engaged in the design, production, and distribution of various textile products. To determine the sample size, a simple random sampling method was employed. Simple random sampling was considered an appropriate approach for this study because of its impartiality and independence from the specific characteristics of individuals or companies. Furthermore, Cochran's formula was used to calculate the sample size accurately, as this formula is widely applied in social and economic research for determining appropriate sample sizes. Based on this formula and considering the predetermined margin of error, 500 questionnaires were distributed among members of the statistical population. On average, four questionnaires were distributed within each company in order to ensure representation of the different dimensions and operational activities of the companies.

Following the distribution of the questionnaires, 550 questionnaires were collected, indicating a high level of participation among respondents in this study. From this number, incomplete questionnaires and those containing invalid data were excluded, and ultimately, 550 valid questionnaires remained for final analysis. It should be noted that, because the unit of analysis in this study was based on companies, the questionnaires were aggregated according to the responding companies, and in the final analysis, the responses were averaged across 185 companies. This procedure contributed to enhancing the accuracy and validity of the research findings.

The required data for this study were collected using a standardized questionnaire developed based on theoretical foundations. The questionnaire possessed a valid and scientific structure and content and was specifically designed to measure the principal variables of the study. To assess the validity of the measurement instrument, face validity was employed. In this method, the questionnaire was provided to a number of university professors and experts in the fields of management and the textile industry. After receiving scientific and specialized feedback from these experts, the necessary modifications were applied to the questionnaire content to ensure more accurate and precise measurement of the research variables. This process enhanced the validity of the questionnaire and established it as a reliable instrument for data collection.

The reliability of the questionnaire was also examined and confirmed using Cronbach's alpha coefficient. Cronbach's alpha coefficient, recognized as one of the most reliable methods for evaluating the reliability of measurement instruments, assesses the internal consistency of questionnaire items. The results of this test demonstrated satisfactory reliability of the questionnaire, indicating its dependability for data collection purposes.

In this study, a standardized questionnaire was employed to measure the impact of Total Quality Management on competitiveness through explaining the mediating role of customer orientation. The main variables investigated in this study included Total Quality Management, customer orientation, and competitiveness. In this regard, the measurement model proposed by Suciati et al. (2024) and Sun et al. (2022) was utilized to assess the various dimensions of Total Quality Management. This model consists of five principal dimensions, including leadership and top management support, employee training and participation, information and learning, process management, and customer focus. These dimensions were specifically incorporated into the questionnaire through 21 different

indicators. A five-point Likert scale (1–5) was used to measure responses, thereby enabling accurate and reliable evaluation of respondents' attitudes.

To evaluate Total Quality Management performance, the research models developed by Permana et al. (2019) and Megirang et al. (2023) were employed. In this study, Total Quality Management performance was examined from two main dimensions, namely customer orientation and continuous improvement, and included 10 indicators specifically evaluated using a five-point Likert scale (1–5).

Competitiveness, as one of the key variables in this study, was measured using the validated questionnaires developed by Perez-Brito and Bojorquez Zapata (2017), as well as Kafetzopoulos et al. (2015). In this questionnaire, competitiveness was assessed across two principal dimensions, namely domestic competitiveness and international competitiveness, through 14 indicators.

To analyze the relationships among latent variables and test the research hypotheses, Structural Equation Modeling (SEM) was employed. Due to its strong capability in analyzing complex relationships among variables and examining the interactive effects of different factors, this method was selected as an appropriate analytical tool for hypothesis testing and data analysis.

Findings and Results

Table 1 presents the demographic characteristics of the respondents. The majority of the participants were male and held a bachelor's degree.

Table 1. Demographic Characteristics of Respondents

Variable	Male	Female	Associate Degree and Lower	Bachelor's Degree	Master's Degree and Higher
Frequency	220	55	38	135	102
Percentage	40.00	10.00	6.91	24.55	18.55

The values of the descriptive statistics for the research variables are presented in Table 2.

Table 2. Descriptive Statistics of the Model Parameters for the Research Variables

Variable	Mean	Standard Deviation	Median	Skewness	Kurtosis	Minimum	Maximum
Total Quality Management	2.91	0.53	2.96	-0.09	-0.17	1.43	4.59
Customer Orientation	2.90	0.73	2.80	0.08	-0.16	1.00	5.00
Continuous Improvement	2.63	0.81	2.60	0.01	-0.61	1.00	4.60
Competitiveness	2.85	0.64	2.78	0.08	-0.52	1.29	4.43

Considering that the skewness and kurtosis values fall within the range of -2 to +2, it can be concluded that the data distribution is approximately normal. To further confirm the normality of the data, the Kolmogorov–Smirnov test was also applied. In this test, if the significance level (p-value) is less than 0.05, the null hypothesis of normal distribution is rejected; otherwise, the assumption of normality is accepted. The results of this test are presented in Table 3 and indicate that the data distribution is acceptably normal. This finding strengthens the validity of the subsequent statistical analyses and permits the application of parametric methods.

Table 3. Results of the Normality Test for the Variables

Statistic	Total Quality Management	Customer Orientation	Continuous Improvement	Competitiveness
Sample Size	185	185	185	185
K–S Test Statistic	0.912	1.307	1.322	0.946
Significance Level	0.377	0.066	0.061	0.332

The results of the Kolmogorov–Smirnov test indicate that the research variables have a normal distribution; therefore, the Structural Equation Modeling (SEM) method can be employed to examine the research hypotheses. This contributes to the validity of the findings and the accuracy of the analyses and ensures that the statistical assumptions required for conducting this type of analysis are satisfied.

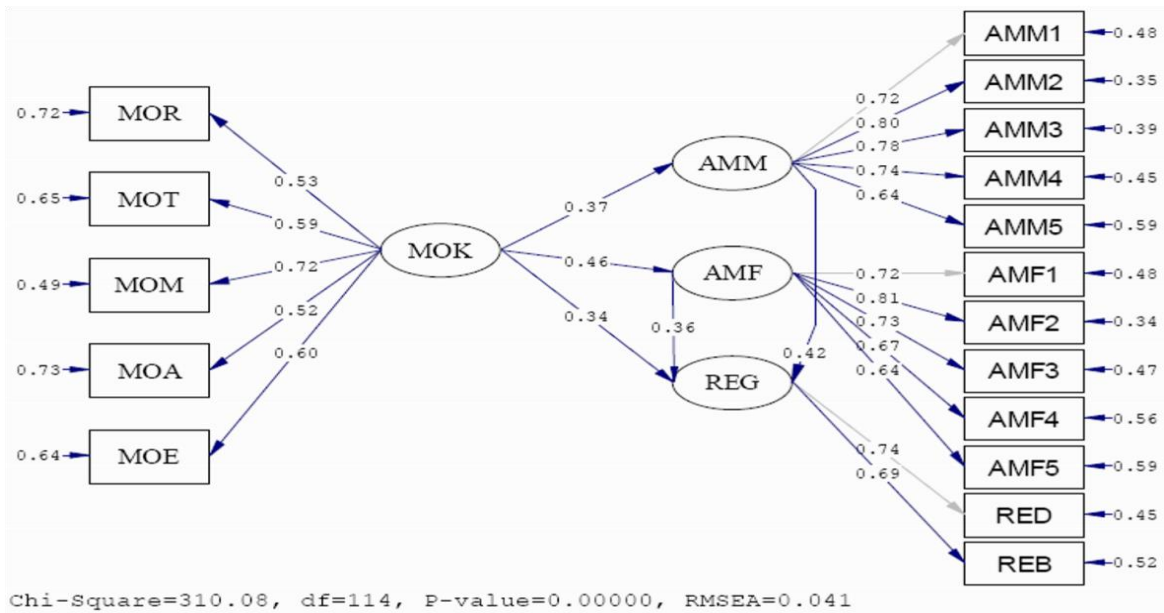


Figure 1. Estimation Model in Standardized Coefficients Mode

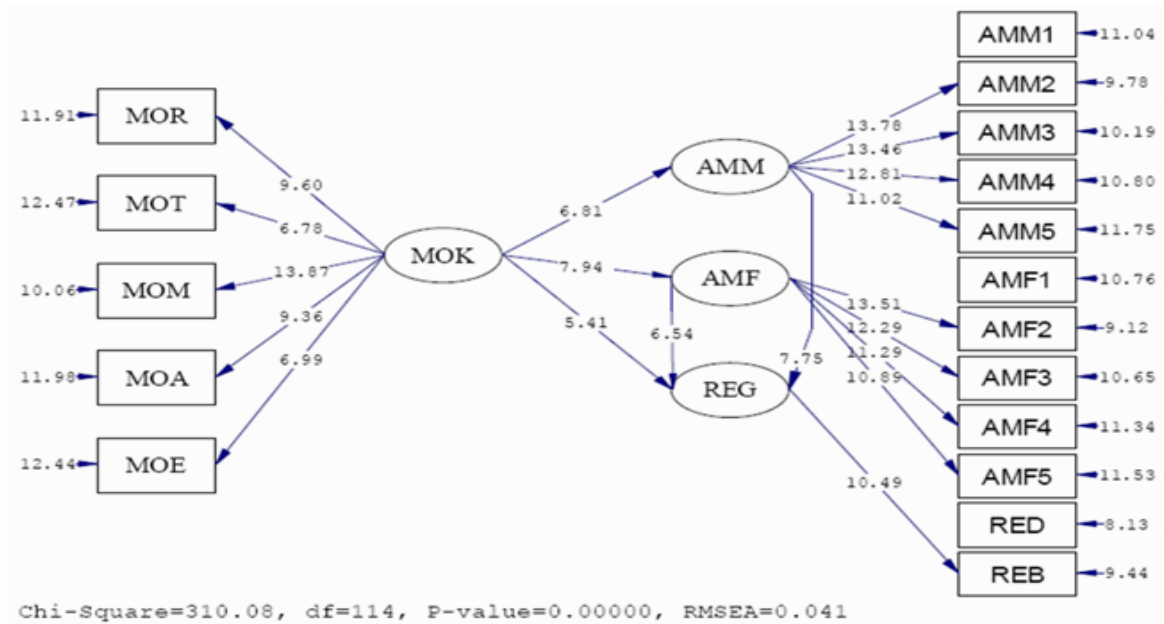


Figure 2. Estimation Model in t-Value Mode

The model tested in this study was analyzed using the Structural Equation Modeling (SEM) approach with the assistance of the LISREL software package, as illustrated in Figures 1 and 2. To evaluate the model fit, several goodness-of-fit indices were calculated. The Root Mean Square Error of Approximation (RMSEA) was obtained as 0.041, which is below the threshold value of 0.08, indicating an acceptable and appropriate model fit. In addition, other fit indices, including the Goodness-of-Fit Index (GFI), Comparative Fit Index (CFI), and Incremental Fit Index (IFI), yielded values of 0.94, 0.93, and 0.95, respectively. All these indices exceeded the reference threshold of

0.90, reflecting the satisfactory performance of the model in fitting the data. Furthermore, the chi-square to degrees of freedom ratio (χ^2/df) was calculated as 2.72, which is below the threshold value of 3, once again confirming the acceptable fit of the model. Therefore, the results derived from the Structural Equation Modeling analysis in this study possess adequate validity and reliability, and the findings can be considered dependable. Other fit indices used in this study are presented in Table 4, together with the output of the tested model.

Table 4 presents the results of the Structural Equation Modeling analysis along with the path coefficients and significance values (t-values) for examining the research hypotheses. Based on the results reported in Table 4, each relationship and hypothesis of the study can be evaluated as presented below.

Table 4. Goodness-of-Fit Indices of the Model

No.	Fit Criterion	Index	Value	Acceptable Threshold	Result
1	Root Mean Square Residual	PMR	0.089	Close to zero	Acceptable
2	Normed Fit Index	NFI	0.93	> 0.90	Very Good
3	Non-Normed Fit Index	NNFI	0.92	> 0.90	Very Good
4	Relative Fit Index	RFI	0.93	> 0.90	Very Good
5	Adjusted Goodness-of-Fit Index	AGFI	0.90	> 0.90	Very Good

In this study, the causal relationships among Total Quality Management, customer orientation, continuous improvement, and competitiveness were tested using Structural Equation Modeling. The results of the path coefficients indicate that all formulated hypotheses demonstrate positive and significant relationships. Based on the findings, customer orientation, continuous improvement, and competitiveness each exert significant and independent effects on Total Quality Management. Among these relationships, the strongest effect was associated with the influence of continuous improvement on Total Quality Management (0.46), whereas the weakest relationship was related to the influence of competitiveness on Total Quality Management (0.34). Furthermore, competitiveness, as a core variable, exerts a direct effect on both major dimensions of Total Quality Management, namely customer orientation and continuous improvement. These findings indicate that the existence of an active and dynamic competitive environment provides the necessary foundation for the development of a customer-oriented culture and commitment to continuous improvement. Total Quality Management is influenced by a combination of internal and external factors, and achieving it requires organizations to strengthen all dimensions related to competitiveness, customer orientation, and continuous improvement. Therefore, organizational planners and decision-makers should simultaneously focus on all these dimensions in order to achieve superior and sustainable performance in today's competitive environments.

Table 5. Path Coefficients and Significance Values of the Research Hypotheses

No.	Path	Standardized Coefficient (Path Coefficient)	t-Value	Significance Level	Result
1	Total Quality Management → Customer Orientation	0.37	6.81	0.000	Confirmed
2	Total Quality Management → Continuous Improvement	0.46	7.94	0.000	Confirmed
3	Total Quality Management → Competitiveness	0.34	5.41	0.000	Confirmed
4	Customer Orientation → Competitiveness	0.42	7.75	0.000	Confirmed
5	Continuous Improvement → Competitiveness	0.36	6.54	0.000	Confirmed

Total Quality Management is recognized as one of the globally acknowledged managerial paradigms adopted by numerous organizations to enhance performance and increase competitiveness. In its essence, this approach

represents an integrated management philosophy designed to continuously improve the quality of products, processes, and services in order to satisfy or exceed customer expectations. Quality experts regard quality management as an essential component for improving organizational performance and consider Total Quality Management to represent the highest level of this approach. This concept is not limited merely to compliance with standards; rather, it emphasizes customer satisfaction and effective responsiveness to customer needs. On the other hand, competitiveness refers to an organization's ability to maintain or improve its market position relative to competitors. Although there is no single universally accepted definition of competitiveness, particularly in small and medium-sized enterprises, the concept generally refers to the ability to consciously manage and utilize organizational capacities and resources through technological innovation, strategic collaboration, access to financial resources, and market penetration in support of key financial and economic indicators. In this context, large companies enjoy considerable competitive advantages due to their greater financial resources. These organizations, through extensive access to capital, can effectively invest in advanced technologies and research and development projects. Their financial stability generally includes abundant liquidity resources, long-term investments, and stable relationships with customers and suppliers, all of which collectively increase their capacity to undertake greater risks. The findings of the present study demonstrate that Total Quality Management, through strengthening customer orientation and continuous improvement, can directly and indirectly influence organizational competitiveness. These findings suggest that the effective implementation of Total Quality Management not only improves quality across various dimensions but also contributes to the creation of sustainable competitive advantage through the enhancement of innovative capabilities.

Table 6. Direct and Indirect Effects of the Mediating Role of the Research Variables

No.	Independent Variable	Mediating Variable	Dependent Variable	Direct Effect	Indirect Effect	Total Effect
6	Total Quality Management	Customer Orientation	Competitiveness	5.41	52.77	58.18
				0.34	0.15	0.49
7	Total Quality Management	Continuous Improvement	Competitiveness	5.41	51.92	57.33
				0.34	0.16	0.50

Total Quality Management demonstrates the same direct effect in both models (5.41 or a standardized coefficient of 0.34) on competitiveness, indicating that Total Quality Management, even without the mediation of other factors, has a significant impact on the competitiveness of industrial activities, particularly in nanotechnology industries. However, more importantly, this effect increases severalfold through the mediating roles of customer orientation and continuous improvement, such that the total effects of both pathways are substantially high, indicating that Total Quality Management strongly enhances competitiveness through these two mechanisms. Comparing the two mediating variables, continuous improvement exhibits a greater indirect and total effect on competitiveness than customer orientation (a standardized coefficient of 0.50 compared with 0.49), highlighting the greater importance of this variable within the chain of influence.

Nanotechnology industries, due to their high sensitivity, require extremely precise quality standards, compliance with international standards, and the capability to rapidly transfer innovation to the market. In this regard, the implementation of Total Quality Management contributes to the improvement of all production, research and development, and after-sales service processes, thereby directly increasing competitiveness. On the other hand, accurately understanding customer needs—often including large corporations, research centers, and

governments—and aligning products and services with these needs through customer orientation plays a major role in enhancing corporate competitiveness. Nevertheless, continuous improvement, as one of the principal pillars of Total Quality Management, is particularly critical in nanotechnology industries because rapid technological changes and the necessity for optimizing production processes and minimizing subtle errors at the nanoscale require the existence of a culture of continuous improvement, which Total Quality Management can effectively reinforce within organizations. Therefore, in the strategic development of nanotechnology industries, special attention to continuous improvement processes can exert a significant effect on enhancing competitiveness.

Discussion and Conclusion

The present study investigated the relationship between Total Quality Management (TQM), customer orientation, continuous improvement, and competitiveness in nanotechnology small and medium-sized enterprises (SMEs). The findings demonstrated that all hypothesized relationships were positive and statistically significant, confirming that TQM exerts a substantial influence on competitiveness both directly and indirectly through customer orientation and continuous improvement. The results further indicated that continuous improvement had the strongest effect on TQM, while competitiveness exhibited the weakest direct relationship with TQM among the tested paths. Additionally, competitiveness significantly influenced both customer orientation and continuous improvement, highlighting the interconnected nature of quality management practices and strategic organizational performance within nanotechnology industries.

The significant relationship between TQM and customer orientation confirms that organizations implementing quality management principles become more responsive to customer needs and expectations. This finding aligns with previous studies emphasizing that customer satisfaction is one of the primary outcomes of effective TQM implementation (15, 16). TQM encourages organizations to develop systematic approaches for identifying customer demands, monitoring satisfaction levels, and improving service and product quality accordingly. In nanotechnology industries, where customers often require highly specialized and technically accurate products, customer orientation becomes even more critical because firms must respond to precise performance requirements and rapidly evolving technological expectations. The findings also support the argument that customer-oriented firms are better positioned to improve market performance and maintain competitive advantages in uncertain and technologically dynamic environments (17). This relationship suggests that nanotechnology SMEs cannot rely solely on technical innovation; rather, they must integrate customer feedback and market intelligence into quality management systems to ensure commercial success.

The positive and significant relationship between TQM and continuous improvement also represents an important contribution of this study. The findings revealed that continuous improvement had the strongest path coefficient among the tested relationships, indicating that it functions as a central mechanism through which TQM enhances organizational performance. This result is consistent with prior literature suggesting that continuous improvement behaviors improve process performance, organizational learning, and operational adaptability (18, 19). In nanotechnology industries, continuous improvement is essential because even minor improvements in production precision, defect reduction, and process optimization can significantly influence product quality and market competitiveness. The findings further support earlier manufacturing studies indicating that organizations practicing continuous improvement are more capable of sustaining quality standards and responding effectively to technological changes (20). Since nanotechnology industries operate within highly sensitive technical environments,

the institutionalization of continuous improvement practices can reduce production errors, improve product consistency, and accelerate innovation commercialization.

Another important finding of the study concerns the direct impact of TQM on competitiveness. The results demonstrated that organizations implementing TQM practices experience enhanced competitiveness in both domestic and international markets. This finding is supported by prior studies that identified TQM as a sustained competitive strategy capable of improving organizational performance over time (33, 34). TQM contributes to competitiveness by improving operational efficiency, strengthening organizational discipline, increasing customer trust, and supporting innovation capabilities. In nanotechnology SMEs, competitiveness depends not only on technological expertise but also on the ability to consistently deliver reliable, standardized, and market-oriented products. Therefore, TQM provides firms with the managerial infrastructure necessary for transforming scientific knowledge into commercially viable products. The findings also align with studies emphasizing that competitiveness in SMEs depends on strategic orientation, resource management, and organizational adaptability (27, 28). By integrating TQM principles into organizational strategy, nanotechnology firms can enhance flexibility, reduce operational inefficiencies, and improve responsiveness to market demands.

The study also demonstrated that competitiveness significantly affects customer orientation and continuous improvement. This finding suggests that firms operating in highly competitive environments are more likely to adopt customer-centered strategies and continuous quality enhancement practices in order to maintain market position. Competitive pressure encourages organizations to continuously monitor market trends, improve production processes, and increase customer satisfaction. This interpretation is consistent with studies indicating that organizations facing intense competition become more innovative and quality-oriented to sustain their market advantage (12, 36). In nanotechnology industries, competition is particularly intense because firms must simultaneously achieve technological superiority, regulatory compliance, and customer trust. As a result, competitive environments can stimulate firms to strengthen quality management practices and pursue operational excellence more aggressively.

The mediating effects of customer orientation and continuous improvement further clarify how TQM contributes to competitiveness. The findings showed that TQM exerts stronger total effects on competitiveness when mediated through these two variables. This result indicates that quality management practices become more effective when organizations successfully translate them into customer-centered strategies and ongoing process improvement initiatives. The stronger mediating effect of continuous improvement compared with customer orientation suggests that the sustainability of competitiveness in nanotechnology industries depends heavily on the organization's ability to continuously refine and optimize its operational systems. This finding aligns with literature emphasizing that innovation and competitiveness are strongly linked to continuous learning and improvement mechanisms (21, 22). Nanotechnology industries operate in rapidly evolving technological environments where products and processes quickly become obsolete; therefore, continuous improvement enables organizations to maintain relevance and sustain competitive capability over time.

The findings of this study also reinforce the importance of integrating TQM with innovation and technological development. Previous studies argued that TQM supports innovation by facilitating organizational learning, knowledge sharing, and process discipline (21, 23). The current results support this perspective because firms with stronger TQM practices demonstrated greater competitiveness and higher commitment to continuous improvement. In nanotechnology SMEs, innovation cannot occur effectively without reliable quality systems because technological

products require precision, safety, and consistency. Therefore, TQM does not hinder innovation; instead, it creates the operational stability necessary for successful technological advancement. This conclusion is further supported by studies highlighting the role of Quality 4.0 technologies in improving organizational productivity, efficiency, and operational control (24, 39). Digital technologies integrated with TQM can help nanotechnology firms improve data accuracy, monitor process performance, and accelerate quality-related decision-making.

The present findings are also consistent with research emphasizing the role of leadership, employee participation, and organizational culture in successful TQM implementation (11, 13). Effective TQM implementation requires commitment from top management and active employee engagement because quality improvement is fundamentally a collective organizational process. In nanotechnology industries, where operations often involve advanced technical procedures and interdisciplinary collaboration, employee participation is particularly important. Employees contribute not only to process execution but also to innovation, troubleshooting, and quality assurance activities. The positive relationships observed in this study suggest that organizations capable of fostering collaborative quality cultures may achieve stronger competitiveness and more sustainable growth.

The findings additionally support studies examining the relationship between TQM and organizational performance in various sectors such as manufacturing, banking, education, insurance, and cooperatives (3-5, 7). Although the contexts differ, the underlying principle remains consistent: organizations that systematically implement quality management practices achieve better operational and strategic outcomes. However, the present study contributes specifically to the nanotechnology context, which has received relatively limited attention in prior TQM research. Nanotechnology industries differ from conventional manufacturing sectors because they involve high technological uncertainty, precision-sensitive processes, and rapid innovation cycles. Therefore, the present study extends the literature by demonstrating that TQM principles remain highly relevant even within technologically sophisticated and innovation-intensive environments.

Another significant implication of the findings relates to SME sustainability and resilience. Previous research highlighted the importance of strategic flexibility, innovation, and adaptive capabilities for SME survival, especially during periods of uncertainty and market disruption (9, 35). The current findings suggest that TQM may function as a resilience mechanism by improving organizational coordination, operational stability, and customer responsiveness. Through continuous improvement and customer orientation, firms become more capable of adapting to changing market conditions and technological challenges. This capability is especially important for nanotechnology SMEs because they often face resource limitations and intense international competition. Access to finance, technological infrastructure, and strategic capabilities are all important determinants of competitiveness (28, 29), yet the present findings indicate that managerial quality systems can significantly enhance the effective utilization of these resources.

The study also confirms the practical relevance of integrating TQM with lean manufacturing and operational excellence approaches. Previous studies showed that lean systems, process optimization, and quality management integration improve productivity and organizational performance (25, 26, 40). The current findings suggest that nanotechnology SMEs can strengthen competitiveness by combining TQM with continuous operational refinement and efficiency-oriented management systems. Since nanotechnology production often involves expensive materials, precise measurements, and technically sensitive procedures, operational inefficiencies can generate substantial financial and strategic losses. Consequently, organizations emphasizing process optimization and quality consistency are more likely to achieve sustainable competitive advantages.

Overall, the findings demonstrate that TQM functions as a strategic managerial system capable of improving competitiveness through customer orientation and continuous improvement. The results suggest that nanotechnology SMEs should not view quality management merely as a compliance requirement but rather as a long-term strategic capability that supports innovation, operational excellence, and market expansion. The integration of customer-centered practices, continuous learning, technological adaptability, and quality improvement creates a comprehensive framework through which firms can sustain competitiveness in highly dynamic technological environments. Furthermore, the study highlights that competitiveness itself reinforces organizational commitment to customer orientation and continuous improvement, creating a cyclical process in which quality management and market performance mutually strengthen one another.

One limitation of the present study is that the data were collected only from SMEs operating within a specific industrial context, which may limit the generalizability of the findings to other sectors or larger organizations. Additionally, the study relied on self-reported questionnaire data, which may be influenced by respondent bias or subjective evaluation. The cross-sectional nature of the research also restricts the ability to examine long-term causal relationships among TQM, customer orientation, continuous improvement, and competitiveness. Furthermore, some contextual variables such as organizational culture, technological maturity, and government policy support were not directly examined in the model.

Future research could investigate the relationship between TQM and competitiveness in other technology-intensive sectors such as biotechnology, artificial intelligence, renewable energy, and advanced manufacturing industries. Comparative studies between SMEs and large corporations may also provide deeper insights into how organizational size influences the effectiveness of quality management practices. Longitudinal studies would be valuable for understanding the long-term effects of TQM implementation on innovation and competitiveness. In addition, future researchers may examine the moderating or mediating roles of organizational agility, digital transformation, leadership style, and knowledge management in strengthening the relationship between TQM and competitiveness.

From a practical perspective, managers of nanotechnology SMEs should prioritize the development of integrated quality management systems that emphasize customer orientation and continuous improvement. Organizations should invest in employee training, process monitoring, customer feedback systems, and innovation-supportive organizational cultures to strengthen competitiveness. Policymakers and industrial development agencies should also support SMEs by providing financial incentives, quality certification programs, and technological infrastructure that facilitate TQM implementation. Firms operating in nanotechnology industries should adopt a strategic perspective toward quality management and integrate quality principles into all operational, research, and market-related activities in order to achieve sustainable growth and long-term competitive advantage.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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References

1. Susiati D, Judijanto L, Suprayitno D, Suarni E. Integration of Total Quality Management (TQM) in Business Practice: A Bibliometric Analysis. *West Science Business and Management*. 2024. doi: 10.58812/wsbm.v2i01.736.
2. Permana A, Purba HH, Rizkiyah ND. A Systematic Literature Review of Total Quality Management (TQM) Implementation in the Organization. 2021.
3. Alali TS. Total Quality Management in the Insurance Sector. 2021.
4. Sungkawati E, editor *Implementation of Total Quality Management (TQM) in Gender-Based Cooperatives*. Proceedings of the International Conference on Community Development; 2020.
5. Mukenga M, Awolusi OD. Total Quality Management and Organizational Performance: A Study of Commercial Banks in Bamako, Mali. *Information Management and Business Review*. 2023. doi: 10.22610/imbr.v15i4(I).3332.
6. Mufidah AM, Yusuf M, Widyastono H. The correlation between total quality management with teacher performance in special education. *Journal of Education and Learning (EduLearn)*. 2025;19(1):416-21. doi: 10.11591/edulearn.v19i1.21198.
7. Wismayanti V, Isjoni I, Azhar A. Impact of Total Quality Management toward Education Quality at Vocational School. *Al-Ishlah: Jurnal Pendidikan*. 2025;17(2). doi: 10.35445/alishlah.v17i2.4701.
8. Garcia M, Kim H. Bridging the Gap: Scaling Nanotechnology Innovations from Lab to Market. *Tech Foresight Quarterly*. 2024;10(1):10-30.
9. Jones A, Lee S. The Agility of SMEs in High-Tech Sectors: A Global Perspective. *Small Business Management Review*. 2022;40(4):301-25.
10. Agotilla EB, Agustin JA. A Baseline Assessment of the Total Quality Management Pillars of Commitment to Quality, Customer Satisfaction and Continuous Improvement in a Manufacturing Concern. *American Journal of Economics and Business Innovation*. 2022. doi: 10.54536/ajebi.v1i3.969.
11. Nawaz Wassan A, Memon MS, Mari SI, Kalwar MA. Identifying the Critical Success Factors of Total Quality Management Implementation in Manufacturing Industry of Pakistan: An Exploratory Factor Analysis. *Journal of Applied Research in Technology and Engineering*. 2023. doi: 10.4995/jarte.2023.17969.
12. Son HV, Trai NV, Tam PT. Managerial Recommendations Improving the Competitive Capability of Firms Based on Total Quality Management During COVID-19 Pandemic. *Emerging Science Journal*. 2022. doi: 10.28991/ESJ-2022-06-03-010.

13. Fatoni A, Saputra BY, Suryasaputra R, Alfinatun T. The Effect of Application of Total Quality Management and Performance Measurement System on Employee Performance through Motivation as an Intervening Variable in Trust Group Surabaya Company. *Review of Politics and Public Policy in Emerging Economies*. 2023. doi: 10.26710/rope.v5i1.2827.
14. Naufal M. Can Total Quality Management Improve Employee Performance? *Bongaya Journal for Research in Management*. 2021. doi: 10.37888/bjrm.v4i1.258.
15. Parhan M, Bakhtiar A. The Relationship Between Total Quality Management and Customer Satisfaction Through the Mediation of Employee Performance. *Jurnal Teknik Industri*. 2024. doi: 10.22219/JTIUMM.Vol25.No2.161-172.
16. Hanum R. Evaluation of the Implementation of Total Quality Management on PT. Aksakindo Manufacturing. *International Journal of Economics*. 2022.
17. Tunc T. The Joint Effects of Customer and Competitor Orientation on Marketing Performance: A Case of an Industry Leading Firm in Turkey. *Istanbul Management Journal*. 2020. doi: 10.26650/imj.2020.89.0003.
18. Brown T, editor *Continuous Improvement Cycles in Fast-Evolving Technological Fields*. Proceedings of the Annual Conference on Manufacturing Excellence; 2023.
19. Ugwu KE. Aligning Total Quality Management, Continuous Improvement for Process Performance: An Empirical Review. *Journal Research of Social Science, Economics, and Management*. 2023. doi: 10.59141/jrssem.v3i02.532.
20. Sesar V, Hunjet A, editors. *The Practice of Continuous Improvement Behaviours in Manufacturing Companies with ISO 9001*. DIEM: Dubrovnik International Economic Meeting; 2021.
21. Pinto CM, Romero FC. The Relationship Between Quality Management and Innovation. *China-USA Business Review*. 2020.
22. Yirga SA, Beshir MA. The Effect of Total Quality Management Practices on Innovation: Evidence from Selected Agricultural Technical and Vocational Education Training Colleges in Ethiopia. *Journal of Innovation and Entrepreneurship*. 2025;14(21):1-26. doi: 10.1186/s13731-024-00460-x.
23. Irannejad N, Shirouyehzad H, Shahin A. Providing a Framework for Performance Evaluation of Organizations in Successfully Implementing TQM, Based on Knowledge Management Approach and Organizational Agility. *Complexity*. 2023;2023:1857596:1-:24. doi: 10.1155/2023/1857596.
24. Santos G, Rebelo MF, Silva R. Exploring the landscape of Quality 4.0: A comprehensive review of its definitions, technologies, and applications. *Total Quality Management & Business Excellence*. 2024;35(2):123-45. doi: 10.1080/21693277.2024.2373739.
25. Ditkaew K. The Effect of Lean Accounting Implementation on Organizational Performance. *International Journal of Asian Business and Information Management*. 2022;13:1-18. doi: 10.4018/IJABIM.309134.
26. Theophilus O. Lean Manufacturing Practices and Organizational Performance: A Literature Review. *International Journal of Innovative Science and Research Technology*. 2024. doi: 10.38124/ijisrt/IJISRT24SEP443.
27. Handoyo S, Mulyani S, Ghani EK, Soedarsono S. Firm Characteristics, Business Environment, Strategic Orientation, and Performance. *Administrative Sciences*. 2023. doi: 10.3390/admsci13030074.
28. Mongkol K. The Impact of Dynamic Capabilities on the Performance of Thai Small and Medium Enterprises. *International Journal of Asian Business and Information Management*. 2022;13:1-13. doi: 10.4018/IJABIM.309102.
29. Vasylichuk I, Izmaylova N, Smyrna O, Petrishyna T, Slusarenko K, editors. *Access to Finance as a Driver Innovation*. SHS Web of Conferences; 2021.
30. Rinayanti Pelealu D. Human Resources Management and Total Quality Management as an Effort to Improve Company Performance. *Majalah Journal of Islamic Finance and Management*. 2023. doi: 10.31538/mjifm.v2i1.23.
31. Syoemantri YF. Improving Business Performance Through Innovation Strategy and Total Quality Management Practice: Survey on the Pharmaceutical Industry in Indonesia. *Hasanuddin Economics and Business Review*. 2021. doi: 10.26487/hebr.v4i3.2203.

32. Maghirang DD, Macarandang NB, Yuliviona R. The Correlation Between Total Quality Management Practices and Employees' Job Performance: Basis for Proposed Sustainable TQM Strategies. *KnE Social Sciences*. 2023. doi: 10.18502/kss.v8i13.13766.
33. Ukab MM. Total Quality Management Practices to Enhance Organizational Performance by Competitive Advantage as Mediating in SMEs in Iraq. *Psychology and Education Journal*. 2021. doi: 10.17762/pae.v58i2.2961.
34. Chen Y, Wang Q. Total Quality Management as a Sustained Competitive Strategy: A Meta-Analysis. *International Journal of Operations Management*. 2023;28(1):45-67.
35. Hidayati R, Rachman NM. Indonesian Government Policy and SMEs Business Strategy During the COVID-19 Pandemic. *NIAGAWAN*. 2021. doi: 10.24114/niaga.v10i1.21813.
36. Adejare BO, Udofia EE, Olaore GO. Strategy Integration, Sustainable Drivers of Firm Internationalization Performance-Moderated by Environmental Uncertainty and Firm Capabilities. *Journal of International Entrepreneurship*. 2023;1-28. doi: 10.1007/s10843-023-00328-3.
37. Zarooni MI. The Effect of Leaders Strategic Improvisation and TQM on SME's Performance: Examining Mediating Role of Corporate Entrepreneurship. 2021.
38. Haikal M, Purwanto S. Analysis of Factors in Efforts to Improve Operational Performance: Study on Clamp Ring Production at PT Pramesta Baja Utama. *Journal of Accounting and Finance Management*. 2024. doi: 10.38035/jafm.v5i4.744.
39. Naveena S, Yokeswari S. Effects on Total Quality Management in Enhancing the Organisation's Productivity and Efficiency Deployment. *International Journal for Multidisciplinary Research*. 2024.
40. Yusof N, Lee K. Improve Product Quality and Production Process with Integration of Six Sigma and Quality Management System ISO 9001: A Case Study of Bakery Shop in France. *International Journal of Industrial Management*. 2022. doi: 10.15282/ijim.14.1.2022.7598.