Proceedings of the 19th International Scientific and Practical Conference «Scientific Horizon in the Context of Social Crises»

(August 16-18, 2026).
Tokyo, Japan

No
305

INTERCONF
Scientific Publishing Center

MANAGEMENT

The Role of Quality Costs in Quality Management Practices on Process Performance and Total Productive Maintenance (TPM): an Integrated Approach

Nariman Hasanov[1]

[1]PhD student;
Yalova University Department of Business Administration, Turkey

Abstract. In recent years, the concept of quality management has evolved beyond ensuring product conformity to encompass process performance, cost efficiency, and sustainable improvement. The aim of this study is to examine the role of quality costs in quality management practices and their impact on process performance and Total Productive Maintenance (TPM) through an integrated approach. The study is designed as a qualitative research based on a comprehensive literature review, focusing on the interrelationships among quality costs, process performance, and TPM. The findings indicate that internal and external failure costs largely reflect deficiencies in process performance, while investments in prevention and appraisal activities contribute to improved process stability and reduced total quality costs. Furthermore, TPM practices are found to enhance equipment reliability, reduce unplanned downtime, and support process performance improvements, leading to a significant decrease in failure-related quality costs. The study concludes that the integrated management of quality costs and TPM strengthens the effectiveness and sustainability of quality management systems.
Keywords: *Quality management, quality costs, process performance, total productive maintenance, integrate.*

---

1. Introduction

Quality management practices today are no longer limited to the goal of "defect-free products"; they have evolved into a management approach where processes are fully managed, losses are measured, and improvement decisions are evidence-based. A key aspect of this transformation is clearly demonstrating the cost of quality improvement efforts to the business and how quality deficiencies affect process performance. ISO 9001's process approach creates a systematic management structure for achieving objectives by integrating the management of processes and their interactions, the PDCA cycle, and risk-focused thinking (International Organization for Standardization [ISO], 2015). This structure necessitates monitoring quality performance not only through outcome indicators but also through deviations and risks that occur within the process.

At this stage, the term "quality costs" is one of the important tools that reveals the economic aspect of quality management. Quality costs are generally divided into four groups: preventive, evaluation, internal failure, and external failure costs; this distinction helps to understand at what stages and why errors and waste occur in processes (American Society for Quality [ASQ], n. d). When we look at the performance of processes, increases in internal and external failure costs generally indicate process losses such as rework, waste, downtime, and customer complaints/returns; while prevention and evaluation costs are investments aimed at preventing these losses before they occur (ASQ, n. d). Therefore, quality costs constitute a "cost indicator" that shows the weak points in process performance and provide an important data source in determining improvement priorities.

Total Productive Maintenance (TPM) is a comprehensive approach that aims to establish a relationship between quality costs and process performance, particularly through equipment-related losses. The main theme of TPM is to increase both productivity and quality by minimizing production-related losses such as equipment failures, unexpected stoppages, and speed losses. Recent research that considers TPM and Total Quality Management (TQM) elements together reveals that these practices significantly impact production success, and this impact is strengthened by integrated management structures (Al-Refaie, 2022). Furthermore, current resources that address TPM in conjunction with Industry 4.0 tools (data collection, analysis, digital monitoring, etc.) emphasize that TPM applications are being reshaped by digital technologies; and that issues such as data collection/integration, competency, and change management are critical to success (Mouhib et al., 2025). This demonstrates that the goals of reducing quality costs and improving process performance can be more firmly linked to TPM's proactive and continuous improvement-based approach.

The main objective of this study is to address the effects of quality costs on process performance and Total Productive Maintenance (TPM) in quality management practices from an integrated perspective. The study aims to explain how the classification of quality costs can be linked to process performance indicators; and how TPM mechanisms for reducing losses and increasing equipment efficiency affect quality costs. In this respect, the article aims to develop a conceptual framework for transforming quality costs from a "reported cost element" into a performance measurement tool managed from a TPM and process perspective.

2. Quality Management and the Concept of Quality Costs

The quality cost approach is one of the most important pillars of quality management practices because it makes process performance "measurable". Quality costs are fundamentally classified as prevention, evaluation (inspection/testing), and failure (internal/external) costs (PAF model), thus making non-value-adding processes visible (Köroğlu, 2024). The aim in this perspective is not only to record costs but also to increase preventive measures before errors occur (prevention), reduce the burden of detecting errors in the process (evaluation), and systematically reduce the internal and external failure costs that cause the highest expense (Köroğlu, 2024). Indeed, establishing a quality cost system correctly acts as an "early warning" mechanism that points to waste in processes and allows managers to determine improvement priorities based on data (Korkmaz, 2016). Therefore, quality costs allow process performance to be evaluated not only through "results" but also through the effectiveness of activities within the process; in other words, it elevates quality management from the accounting and reporting level to the process management level (Korkmaz, 2016).

When examining process performance, a bidirectional relationship is observed between quality costs and performance indicators: As process efficiency increases, there is a decrease in failure rates, rework, scrap, and external failures such as warranties/returns; this, in turn, increases delivery reliability, cycle times, and customer satisfaction (Köroğlu, 2024). However, the literature indicates that simply increasing "control and inspection" is not sufficient for sustainable performance; the real impact stems from process improvement practices such as prevention-oriented design, standardization, and root cause analysis (Korkmaz, 2016). This directly links the understanding of quality costs to process management: Although prevention costs are often seen as "additional costs," they contribute positively to total cost and process completion time by reducing failure costs (Köroğlu, 2024). Therefore, quality costs offer a financial assessment of the question "which stage should be improved?" in process management and help prioritize improvement projects (Kaizen projects, process redesign, standardization, etc.) (Korkmaz, 2016).

In this context, Total Productive Maintenance (TPM) stands out as a holistic management approach that targets "equipment-related losses" between process performance and quality costs. The aim of TPM is to maximize equipment efficiency and achieve zero downtime and zero defect targets by eliminating losses such as failures and downtime; this directly affects process capacity, flow continuity, and product quality (Göktaş, 1997). In an example of an open-access application, it is stated that TPM contributes to operational flow by reducing downtime and increasing equipment efficiency; furthermore, it is expressed that the aim is to achieve ideal levels of equipment effectiveness (OEE approach) (Göktaş, 1997). From a process management perspective, this brings up two important results: (i) improvement in cycle time and delivery performance is achieved by reducing unplanned downtimes, (ii) internal failure costs (scrap and rework) are reduced by decreasing quality deviations originating from the equipment, creating a downward effect on the overall cost of quality (Göktaş, 1997).

The integration of quality costs with TPM becomes clear, particularly through the lens of “failure costs.” Equipment failures not only lead to maintenance costs but also increase internal failure costs through chain reactions such as production loss, work-in-process damage, readjustment/installation loss, and quality issues. When reflected on the customer side, it can increase external failure costs such as returns, warranty losses, and reputational damage (Göktaş, 1997; Köroğlu, 2024). Therefore, an integrated approach requires tracking maintenance-related differences in quality cost reporting with a separate analytical structure; and using quality cost findings in TPM applications in line with “critical equipment-critical process” prioritization (Korkmaz, 2016). In other words, quality costs help determine, based on data, where TPM should begin and which equipment it should focus on; while TPM supports the continuous reduction of quality costs by reducing variability in the process (Köroğlu, 2024; Göktaş, 1997).

Recently, this holistic perspective has become easier to implement thanks to digitalization and data-driven management practices. Accurate measurement, reporting, and sustainability of quality costs support process improvement decisions based on "evidence," while also institutionalizing the alignment between maintenance, quality, and production (Köroğlu, 2024). On the other hand, treating quality costs solely as an output produced by the accounting department can limit the process's development potential; the literature emphasizes the necessity of an improvement cycle based on root cause analysis and process design, in addition to measurement (Korkmaz, 2016). The success of the integrated approach is evident here: Quality costs answer the question "how much have we lost?", TPM answers "why have we lost it and how can we prevent it?", and process management answers "how do we standardize and continuously improve the flow?" within the same framework (Göktaş, 1997; Köroğlu, 2024).

3. The Relationship Between Process Performance and Quality Costs

Process performance is a key performance metric that shows how effectively, efficiently, and consistently a firm's production and service processes achieve their defined goals. In the field of quality management, process performance is evaluated using criteria such as cycle time, failure rate, rework, scrap amount, delivery reliability, and customer complaints. The common point of these criteria is that they directly reveal the losses caused by quality deficiencies in the process. Therefore, there is a reciprocal and structural link between process performance and quality costs (Korkmaz, 2016).

The quality cost approach plays a significant role in making visible the costs of performance losses in processes. In particular, internal failure costs (waste, rework, sorting, downtime) and external failure costs (returns, warranties, customer loss, reputational damage) arise as direct consequences of inadequacies in processes. It is observed that these costs increase rapidly when processes are not adequately controlled, standards are unclear, or equipment reliability is low (Köroğlu, 2024). Therefore, quality costs can be examined as a financial reflection of deficiencies in process performance.

On the other hand, evaluating quality costs solely based on "outcome" costs is insufficient for improving process performance. Research specifically highlights the positive effects of preventive and assessment costs on process performance. Preventive actions (standardization, training, process design, maintenance planning) and assessment actions (control, measurement, monitoring) facilitate the early detection of errors in the process and intervention at root causes. Although these actions may seem like increased costs in the short term, in the medium and long term they reduce internal and external failure costs, thus contributing to a decrease in total quality costs and an improvement in process performance (Korkmaz, 2016; ASQ, n.d.).

The link between process performance and quality costs can be made more apparent by tracking quality costs in a process-oriented manner. Process-oriented quality cost analysis reveals which type of cost is concentrated at which process stage, allowing improvement efforts to be guided in a data-driven rather than intuitive way. This method transforms quality costs from being merely an element of accounting reports into an active decision-making tool in process management (Başbuğ, 1997).

In this context, improving process success can be considered a crucial condition for reducing quality costs. Increased process efficiency means reduced error rates, shorter processing times, and more streamlined production flows; this, in turn, helps achieve a continuous reduction in both internal and external error costs. Research addresses this relationship as "quality costs are a result, process performance is a cause," suggesting that sustainable cost improvement can only be achieved through the replanning and meticulous management of processes (Köroğlu, 2024).

Consequently, the relationship between quality costs and process performance is not a unidirectional causal one, but rather a dynamic and cyclical one. Improvements in process performance reduce quality costs, while regularly monitoring quality costs increases the accuracy of decisions aimed at improving process performance. This reciprocal interaction demonstrates the necessity of addressing quality management practices with a process-oriented and holistic approach.

4. Total Productive Maintenance (TPM) Approach and Process Performance

Total Productive Maintenance (TPM) is an integrated maintenance and management method aimed at ensuring equipment in manufacturing systems operates at peak efficiency throughout its lifecycle. Departing from the traditional understanding of maintenance, TPM examines maintenance activities not merely as a technical task, but as an integrated structure within production, quality, and management processes. The main objective of this approach is to eliminate equipment-related losses, ensure process continuity, reduce unplanned downtime, and stabilize production performance (Göktaş, 1997).

In TPM literature, process success is generally analyzed through equipment efficiency. The most frequently used metric in this analysis is Overall Equipment Effectiveness (OEE), which reveals how effectively equipment utilizes the planned production time by evaluating availability, performance, and quality elements together. One of the most important goals of TPM applications is to increase OEE rates by systematically reducing failures, adjustments/changes, minor stoppages, speed losses, quality defects, and initial losses, which are referred to as the "six big losses" (Nakajima, 1988).

When evaluated in terms of process performance, insufficient equipment reliability leads to production stoppages, extended cycle times, and quality deviations. This condition increases not only the production quantity but also the error rates and the need for rework in the process. In open-access applications and theses, it has been shown that TPM makes the production flow more predictable by reducing the frequency of failures and unplanned downtime (Göktaş, 1997; Korkmaz, 2016). Thus, it has a positive impact on delivery reliability and process stability.

TPM's contribution to process efficiency is not limited to reducing downtime. TPM elements such as autonomous maintenance, scheduled maintenance, and continuous improvement strengthen operators' interaction with machines, enabling early detection of minor errors and addressing root causes. This helps prevent quality defects in the process, contributing to a reduction in internal failure costs (Köroğlu, 2024). Therefore, it can be concluded that TPM can be seen as a mechanism that supports process performance in terms of both time and quality.

In relation to quality costs, TPM strengthens activities that can be considered, particularly within the scope of preventive costs. Although TPM practices such as planned maintenance, training, and equipment standardization require a certain cost in the short term, they provide a significant reduction in internal and external failure costs in the long term. In the literature, this is interpreted as TPM transforming the quality cost structure into a "preventive-oriented" structure (Korkmaz, 2016; Köroğlu, 2024).

In conclusion, TPM plays a crucial role in sustainably improving process performance. Through TPM applications, equipment-related uncertainties are reduced, production flow becomes more balanced, and lasting improvements are achieved in process performance indicators. These improvements lead to a reduction in quality costs, particularly failure factors, and increase the cost-effectiveness of quality management practices. In this respect, TPM stands out as a strategic tool that strengthens the link between quality costs and process performance.

5. Integration of Quality Costs and TPM: A Holistic Model

Integrating quality costs with Total Productive Maintenance (TPM) allows quality management practices to shift from a results-oriented approach to a preventive and process-oriented one. While quality costs reveal the financial dimension of losses in processes, TPM aims to systematically eliminate the equipment-related causes of these losses. Therefore, considering both approaches together creates a holistic effect that strengthens process performance both technically and economically (Korkmaz, 2016).

The first dimension of integration is the examination of quality costs on a process and equipment basis. Waste, rework, and unexpected downtime, which are among the internal failure costs, are generally linked to equipment reliability, lack of maintenance, or setup errors. TPM practices reduce the occurrence of such losses through methods such as planned maintenance, autonomous maintenance, and root cause analysis, thereby lowering internal failure costs (Göktaş, 1997). In this respect, quality cost reports can be used as input in decision-making processes for "critical equipment" and "critical process" selections within the framework of TPM.

The second dimension is to implement a structural change among the elements of quality costs. According to research, with the increase in TPM (Total Quality Management) practices, the quality cost structure becomes more prevention and evaluation-oriented, while internal and external failure costs decrease (Köroğlu, 2024). Although this change may be perceived as an increase in prevention costs in the short term, in the long term it results in a decrease in total quality costs and the regularization of process performance. Therefore, the integrated approach requires considering quality costs not as "expenses to be avoided" but as strategic investments that maintain process performance.

The third dimension is the simultaneous monitoring of process performance indicators such as OEE, cycle time, delivery reliability, and failure rate, along with quality costs and TPM practices. OEE, within TPM, comprehensively reveals equipment-related losses, while quality costs demonstrate the financial impact of these losses. Evaluating these two data sets together shows which maintenance and improvement efforts on equipment or processes are truly resulting in cost reduction and performance improvement (Nakajima, 1988; Korkmaz, 2016). This ensures that process improvement decisions are based on concrete data rather than an intuitive approach.

The success of the integrated model depends not only on the availability of technical tools but also on the need for organizational alignment and cultural change. Employee involvement in the process, a key principle of TPM, is vital in reducing quality costs. Operators undertaking tasks such as monitoring equipment status, performing minor maintenance, and reporting quality problems in a timely manner both increases process efficiency and reduces internal failure costs (Göktaş, 1997). This demonstrates that the integration of quality costs and TPM is not merely a technical approach but also a human-centered management philosophy.

Finally, the integrated approach has a positive impact on the sustainability of quality management practices. Regularly monitoring quality costs and updating TPM practices based on this information helps the continuous improvement cycle (PDCA) function effectively. The literature indicates that companies where quality costs and TPM are considered together exhibit more consistent process performance, and quality improvements provide lasting benefits rather than temporary gains (Köroğlu, 2024; Korkmaz, 2016). In this context, the integrated model offers strategic guidance for quality management practices.

6. Literature Review and Discussion

Literature examining the relationship between quality costs, process performance, and Total Productive Maintenance (TPM) shows that more consistent and sustainable improvements in production efficiency are achieved when these three elements are managed together. Open-access theses and articles emphasize that monitoring quality costs on a process basis reveals where errors, rework, and unexpected downtimes are concentrated, thus highlighting improvement priorities (Korkmaz, 2016; Köroğlu, 2024). These findings suggest that quality costs should be considered not merely as a financial reporting tool, but as a decision support system contributing to process management.

Studies on process performance reveal that, within quality costs, internal failure components are closely related to performance issues such as extended cycle time, flow imbalance, and reduced delivery reliability (Başbuğ, 1997; Korkmaz, 2016). However, it is widely accepted in academic literature that while increasing preventive and evaluation costs may be seen as a short-term cost increase, it reduces total quality costs and coordinates process performance in the medium and long term (ASQ, n. d.). In this context, the crucial point to consider is not just "how much" the quality costs are, but "in which process and for what reason" they occur; because cost analyses conducted without establishing a process context limit the effectiveness of improvement.

Literature on TPM emphasizes the critical impact of equipment reliability on process performance. It is reported that TPM practices make production flow more predictable by reducing the frequency of failures and unexpected downtime, which directly reduces quality defects and internal failure costs (Göktaş, 1997). Particularly in businesses where independent maintenance and planned maintenance processes are widespread, continuous improvements in process performance indicators are achieved with the reduction of equipment-related fluctuations (Köroğlu, 2024). These findings demonstrate that TPM has not only an indirect but also a cause-and-effect relationship with quality costs.

Research examining the integration of quality costs and TPM shows that better performance results are achieved when these two methods are applied together compared to individual approaches. In integrated systems, quality cost reports are used as a data source in identifying “critical equipment” and “critical maintenance operations” within the TPM framework; furthermore, TPM results support this by showing in which areas improvements have been made in quality costs (Korkmaz, 2016). This reciprocal interaction helps the continuous improvement cycle (PDCA) to function more efficiently. In the literature, this situation is explained by defining quality costs as an “indicator of results” and TPM as a “tool for addressing the causes” (Köroğlu, 2024).

Another noteworthy aspect of the discussion is the organizational and cultural dimensions of the integrated approach. Research indicates that the success of TPM implementations is directly linked to employee participation and top management support; furthermore, it is emphasized that quality cost systems, when managed solely by the accounting department, cannot adequately contribute to process improvements (Başbuğ, 1997; Göktaş, 1997). These results demonstrate that the integration of quality costs and TPM necessitates the development of a participatory and process-oriented management culture, going beyond being merely a technical toolkit.

A notable deficiency in recent studies is the insufficient quantitative and comparative research on the integration of quality costs and TPM. Most existing research focuses only on a specific business or sector, making generalizations difficult (Korkmaz, 2016; Köroğlu, 2024). This presents a significant opportunity for future research. Comparatively examining the relationship between quality cost structures and TPM maturity levels across different sectors will make valuable contributions to the literature.

7. Conclusion and Recommendations

This study examines the impact of quality costs on process performance and Total Productive Maintenance (TPM) from a holistic and integrated perspective. The existing literature demonstrates a strong and reciprocal interaction between quality costs, process performance, and TPM. In particular, examining quality costs on a process basis offers the opportunity to understand performance problems not only through the results themselves, but also through the process and equipment-related factors that cause these results (Korkmaz, 2016; Köroğlu, 2024).

Research findings reveal that one of the most significant consequences of weaknesses in processes is the cost of both internal and external failures. Cost items such as scrap, rework, unexpected downtime, and customer complaints indicate insufficient process control and inadequate preventative measures. On the other hand, it is clearly shown in the literature that investments in prevention and evaluation reduce total quality costs and stabilize process performance in the medium and long term (American Society for Quality, n.d.; Korkmaz, 2016).

The TPM method strengthens the link between quality costs and process performance, especially in terms of equipment effectiveness. Thanks to TPM applications, equipment failures, unexpected stoppages, and speed losses are reduced;

this ensures the continuity of the production flow and prevents quality problems. These improvements, monitored with indicators such as OEE, contribute to a significant reduction in quality costs, particularly in the internal failure categories (Göktaş, 1997; Köroğlu, 2024). Therefore, TPM can be considered not only a supportive but also an effective tool in reducing quality costs.

Considering quality costs and TPM as a whole makes quality management practices more strategic and sustainable. Quality cost data is used in TPM to determine key equipment and maintenance priorities, while TPM results are validated by changes in quality costs. This reciprocal relationship transforms quality management from intuitive decisions into a data-driven and process-based structure (Korkmaz, 2016).

Considered by practitioners, the main recommendation of this study is to ensure that quality costs are used not only for accounting or reporting purposes, but also as a management tool that improves process performance. It is recommended that businesses examine quality costs on the basis of processes and equipment, plan TPM activities in line with this data, and monitor performance indicators (OEE, error rate, cycle time) together with quality costs (Göktaş, 1997). Additionally, for TPM to be successful, ensuring employee participation and the presence of senior management support is extremely important for the sustainability of an integrated approach.

Considering future research, there is a need for comparative empirical studies across different sectors that test the relationship between quality costs, TPM, and process performance based on quantitative data. Furthermore, examining the impact of current practices such as digitalization, predictive maintenance, and data analytics on quality costs and TPM integration will make significant contributions to the literature. From this perspective, this study provides a framework for developing process-oriented and integrated methods in the field of quality management.

References:

[1] Al-Refaie, A. (2022). The relationships between the pillars of TPM and TQM and their effects on manufacturing performance. Sustainability, 14(3), 1497.
[2] American Society for Quality. (n.d.). Cost of quality (COQ).
[3] American Society for Quality. (n.d.). Cost of quality (COQ). https://asq.org/quality-resources/cost-of-quality
[4] American Society for Quality. (n.d.). Quality glossary: Quality costs.

MANAGEMENT

[5] Başbuğ, Ş. (1997). Quality costs (Master's thesis, Uludağ University Institute of Science). Bursa Uludağ University Open Access.
[6] Göktaş, C. (1997). Total Productive Maintenance and Evaluation of Total Productive Maintenance Practices at Kordsa (Master's Thesis, Istanbul Technical University, Institute of Science). ITU Institutional Archives.
[7] International Organization for Standardization. (2015). The process approach in ISO 9001:2015 (Guidance PDF).
[8] Korkmaz, G. (2016). Measurement of quality costs and their application in a company (Master's thesis, Uludağ University Institute of Social Sciences). Bursa Uludağ University Open Access.
[9] Köroğlu, Ç. (2024). Calculation, implementation and sustainability of quality costs. Accounting and Auditing Perspectives, (73), 105-122.
[10] Mouhib, Z., et al. (2025). Total productive maintenance and Industry 4.0: A literature review. Inventions, 8(4), 98.
[11] Nakajima, S. (1988). Introduction to TPM: Total productive maintenance. Productivity Press.
[12] Göktaş, C. (1997). Total Productive Maintenance and Evaluation of Total Productive Maintenance Practices at Kordsa (Master's Thesis, Istanbul Technical University, Institute of Science). ITU Institutional Archives.