

Cost of Quality Management: Encouraging Business Leaders to Manage and Invest in Quality Enhancement

Nesrine Hakem,  ORCID: <https://orcid.org/0009-0000-5829-7247>

M.A., National Higher School of Management, Algeria

Mehdi Bouchetara,  ORCID: <https://orcid.org/0000-0001-9826-8985>

Ph.D., Assistant Professor, Class “A”, National Higher School of Management, Algeria

Wissam Belimane,  ORCID: <https://orcid.org/0000-0003-2302-0031>

Ph.D., Assistant Professor, Class “B”, National Higher School of Management, Algeria

Mustapha Amokrane,  ORCID: <https://orcid.org/0000-0002-8563-9123>

Ph.D., Professor, National Higher School of Management, Algeria

Corresponding author: Nesrine Hakem, hakemnesrine6@gmail.com

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Abstract: *The quality management is a complex set of constant activities aimed at improving the quality of products and services, regularly evaluating and monitoring it, preventing defects, limiting and reducing malfunctions, and correcting production defects before and after the sale of goods. Ineffective quality management leads to such problems as product returns, claims, replacement or repair, loss of customer base, damage to brand reputation, etc. This paper aims to analyze advanced strategies, methodologies, methods and tools for effective control of quality management costs, ways and means of their strategic integration into the practice of business quality management, emphasize the importance of optimizing the cost of quality management in enterprises. The proposals developed in this article are demonstrated on the example of the woodwork division of MEKKERA (MDM), a subsidiary of the HASNAOUI Group in Algeria. An approach represented in the article combines qualitative and quantitative methods. Qualitative data collection involved semi-structured interviews with four company managers, processed using NVIVO software. The purpose of these interviews was to understand the reasons that led the company to include the evaluation of the Cost of Quality in its quality objectives for 2023, as well as the perspectives and goals aimed for by the company in this initiative. A Quantitative analysis relied on secondary data from the company's database: direct quality costs were calculated using the P-A-F and Ferrebœuf models, prevention and detection measures' effectiveness and production process performance were evaluated; key performance indicators for indirect quality acquisition costs were defined. Findings revealed the company exceeded set thresholds for internal and external failure costs, necessitating improvements. Ishikawa method identified causes, and corrective actions were proposed using Failure Mode and Effects Analysis (FMEA).*

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INTRODUCTION

In a highly competitive business context, quality has become a crucial issue for organizations, enabling them to survive and sustain their operations successfully. Many companies view quality not only as a foundational customer value but also as crucial for maintaining a competitive market position. Achieving and maintaining a high level of quality requires investments in time, resources, and additional costs, known as the costs of quality. Therefore, understanding and managing these costs are essential for organizations that are serious about enhancing their performance. Effective management of the costs of quality involves establishing systems to measure and evaluate quality-related expenditures, thereby optimizing resource allocation and ensuring overall business performance.

Within the framework of rigorous cost management, it is crucial to adopt a pragmatic approach. Even a concise analysis can quickly identify improvement opportunities, define unprofitable practices, and generate benefits (Poncelet, 2013). At the heart of this dynamic lies the central issue of the study: **How can Costs of Quality be effectively managed within a company?** This question, the true linchpin of the research, raises significant strategic challenges, demanding a thoughtful and integrated approach to reconcile quality imperatives with budgetary constraints.

The primary objective of quality cost analysis is to connect improvement activities with associated costs and customer expectations. Consequently, this analysis guides actions towards reducing the costs of quality attainment and increasing the benefits derived from quality improvement. Therefore, a realistic estimation of quality attainment costs, representing a proper balance between conformity and non-conformity costs, should be considered a key element of any quality initiative and a major concern for managers. Furthermore, this analysis will enable managers to make informed decisions on how to allocate resources to effectively and efficiently improve quality, reducing non-quality costs and maximizing quality benefits (Abouzahir et al., 2003; Lessomo et al., 2019; Schiffauerova & Thomson, 2006). Indeed, quality costs encompass a complex array of expenses to prevent defects and rectify quality errors.

Despite their widespread recognition, the relevance of their assessment still struggles to translate into the daily practice of businesses (Ayach et al., 2019). It is important to emphasize that the cost of quality management is not limited to mere accounting activity. It should be integrated into the overall management of an organization's quality and used to improve the quality of products and services offered continuously. Thorough evaluation, regular measurement, and proper presentation of quality-related costs enable managers to make informed decisions and design action plans to improve quality while reducing costs of non-quality (Berland et al., 2013; Lassalle, 2022).

This study aims to develop a comprehensive cost management system to enhance quality management practices scientifically, demonstrated using an example from MEKKERA Carpentry (MDM). Furthermore, it seeks to extend beyond issue identification by exploring advanced strategies and methodologies for effective quality cost management. Concurrently, the objective is to transcend mere acknowledgement of these issues by exploring avenues and means for efficient quality cost management. The goal is to provide actionable solutions to reduce non-conformance costs, optimize quality-related costs, and enhance the effectiveness of the company's quality strategy. Through the research, the methods and tools available for quality cost management will be comprehensively understood and strategic integration within business quality management practices will be analyzed. In this light, this introduction marks the beginning of exploring modern quality management, aiming to provide a thoughtful perspective on the challenges and opportunities in this essential area of business management.

LITERATURE REVIEW

Companies continually strive to improve the quality of their products and services while reducing costs associated with quality defects (Asada et al., 2021). To achieve this objective, they must adopt a strategy that manages both the costs associated with ensuring a certain level of quality and those associated with non-quality. Many studies have been conducted on Cost of Quality (COQ) management to develop theories and models in this field. In general, research on COQ is typically classified into four distinct categories. Firstly, conceptual articles focus on advancing theoretical models and definitions of COQ. The second category encompasses industry studies based on smaller samples and exploring different aspects of COQ. The third category includes numerous case studies, some incorporating short-term time series analyses. Finally, several simulation exercises examine the dynamics of quality costs using mathematical models (Plewa et al., 2016).

Various researches highlight the importance of managing the cost of quality in enhancing quality performance and optimizing overall costs in the long term (Biadacz, 2021; Sturm et al., 2019). According to Velkoska and Tomov (2022), this method helps identify areas where costs of quality are highest. It assists companies in making informed decisions on how to allocate resources to effectively enhance quality, reduce

non-quality costs, and maximize quality benefits. However, it is also important to note that despite the growing recognition of the importance of managing costs of quality (Glogovac & Filipovic, 2018), the utilization of this practice remains limited. Few companies have a formal system to identify, measure, and manage costs of quality (Ayach et al., 2019). On the other hand, several studies have focused on developing approaches, such as that presented by Velkoska et al. (2018), which introduces an algorithm for sequentially measuring the costs of quality. This approach incorporates proactive management, quality assurance ecology, and integrating quality and accounting experts. Furthermore, mechanisms and systems have been developed by Lessomo Evola et al. (2019) and Aneesh and Ajith (2016) to address and reduce costs associated with non-quality. These studies consider risks related to non-quality and utilize quality tools to identify gaps, define necessary actions to reduce these costs, and formulate recommendations for achieving quality at the lowest possible cost.

Cost of Quality

The first author to discuss the cost of quality was Joseph Juran in his book “Quality Control Handbook”, published in 1951. Juran put into practice and validated the hypothesis that “as prevention costs increase, the costs of rejections and rework decrease” (Poncelet, 2013, as cited in Juran, 1951). According to Poncelet (2013), the cost of quality (CoQ) refers to the expenses associated with the design, implementation, and maintenance of an effective quality assurance system within a company. Furthermore, Velkoska and Tomov (2021) state that quality costs encompass all expenditures to prevent quality problems and costs incurred due to poor quality. These costs can be perceived as the difference between actual costs and the ideal costs required to achieve quality.

Types of Cost of Quality

Continuous improvement of product and service quality and the reduction of costs associated with quality defects are ongoing objectives in companies. It is crucial to understand the different types of costs related to quality to achieve these goals (Asada et al., 2021). According to studies conducted by Berland et al. (2013) and Ferrebœuf (2000), two types of Cost of Quality can be distinguished:

a. *Direct costs of quality*, which can be further divided into two categories:

- **Controllable Costs (CC):** These are voluntary expenses incurred to maintain a certain level of quality. They can be further categorized as:
 - **Prevention Costs (CP):** These expenses are related to implementing measures aimed at preventing errors and quality defects in the process. In other words, these are costs incurred to limit and reduce malfunctions. This may include activities such as employee training, development of quality standards, supplier management, etc.
 - **Detection Costs (CD):** These are costs related to inspection, testing, and monitoring the quality of products or services. This may include purchasing quality control equipment, compliance testing, etc.
- **Resultant Costs (CR):** The following are distinguished:
 - **Internal Failure Costs (DI):** These correspond to expenses related to products and services that do not meet requirements before leaving the company. These costs are incurred when non-conformities are detected internally, before the product or service is delivered to customers or end-users.
 - **External Failure Costs (DE):** These refer to expenses related to products and services that do not meet requirements after leaving the company. These costs occur when non-conformities are identified by customers or end-users, resulting in issues such as product returns, claims, replacements, or repairs.

b. *Indirect costs:* Indirect costs, intangible costs, are expenses that cannot be easily quantified. They include elements such as loss of customer base, damage to brand reputation, etc. These costs are often difficult to evaluate accurately because they are not directly measurable in monetary terms, but they can have a significant impact on a company’s profitability and reputation.

By understanding the different types of quality costs, organizations can implement appropriate management strategies, specifically focusing on controlling costs (CC) to reduce resulting costs (CR) and improve their overall performance (Ferrebœuf, 2000).

Cost of Quality Models

Evaluating and measuring Cost of Quality (COQ) helps identify areas for quality improvement, allocate resources effectively, and make appropriate decisions to enhance overall performance. This is accomplished using approaches known as Cost of Quality models. Different models have been developed to explain the

concept of Cost of Quality (COQ). In their study, Schiffauerova and Thomson (2006) provide an overview of the most discussed models in the literature. They distinguish five COQ models, each classifying costs into categories. They also highlight the particular attention given to the Prevention-Appraisal-Failure (PAF) model, widely used in practical applications. This model categorizes COQ into different types of costs, such as prevention, appraisal, and failure costs (internal and external). Furthermore, the PAF model has been expanded to include intangible costs and opportunity costs, which represent potential profit losses due to quality problems that are difficult to quantify.

On the other hand, Crosby distinguishes between the cost of conformance and the cost of non-conformance. In this perspective, another model similar to Crosby's is the Process Cost model. This model focuses on cost systems related to obtaining quality, emphasizing the process rather than the products or services (Schiffauerova & Thomson, 2006). Additionally, the ABC model, developed by Cooper and Kaplan, is considered better suited for quality cost measurement systems than traditional accounting. Its use in determining the COQ provides an interesting alternative (Lawrence & Hannelie, 2019). However, it is important to note that this model is not specifically designed as a COQ model. It is an alternative approach that can be used to identify, quantify, and allocate costs related to obtaining quality among products, which can contribute to better cost control of quality (Douiri et al., 2015).

Table 1 illustrates the COQ models classified into 5 groups as categorized by Schiffauerova and Thomson (2006):

- The P-A-F model (Prevention-Appraisal-Failure)
- The Crosby model
- The Opportunity or Intangible Cost model
- The Process Cost model and the Activity-Based model
- The Process Cost model and the ABC (Activity-Based Costing) model

Table 1. Generic Models of Cost of Quality (COQ) and Cost Categories

Generic Model	Cost/Activity Categories
P-A-F	P-A-F Prevention + Appraisal + Failure
Crosby's Model	Conformance + Non-conformance
Opportunity or Intangible Cost Models	Prevention + Appraisal + Failure + Opportunity Conformance + Non-conformance + Opportunity Tangibles + Intangible Assets
Process Cost	Conformance + Non-conformance
ABC Models	Value-Added + Non-Value-Added

Source: Schiffauerova and Thomson (2006)

From Table 1, it is clear that different COQ models categorize quality-related costs in varying ways, reflecting their unique approaches to quality management. The P-A-F model, for instance, focuses on the traditional breakdown of prevention, appraisal, and failure costs, providing a straightforward framework for identifying and managing quality costs. Crosby's model simplifies this further by classifying costs into conformance and non-conformance categories. This can help organizations quickly identify whether their expenditures are geared towards maintaining quality standards or addressing failures.

The Opportunity or Intangible Cost models add another dimension, including opportunity costs and intangible assets. This approach acknowledges that poor quality can lead to missed opportunities and damage to intangible assets like brand reputation, which are crucial for long-term success. The Process Cost model's emphasis on conformance and non-conformance aligns closely with Crosby's model but is often applied in a more process-oriented context, focusing on the cost implications of meeting or failing to meet process standards.

Lastly, the ABC models distinguish between value-added and non-value-added activities, encouraging organizations to optimize their processes by eliminating activities that do not add value to the product or service. These models provide valuable frameworks for companies to analyze and manage quality-related costs. By understanding and applying these models, businesses can strategically invest in quality improvement initiatives that reduce costs and enhance overall performance and customer satisfaction.

METHODOLOGY

The choice of research method depends on various factors, such as reviewing existing literature, as well as the specific objective of our study. Indeed, a literature review enables to understand previous research conducted on our topic of interest, the methodologies used, and the results obtained. A mixed approach was opted to frame and organize the study optimally and ensure a smooth progression through the various stages, leading to satisfactory results. This approach combines quantitative and qualitative approaches either

simultaneously or sequentially. It allows for gathering both qualitative and quantitative data on the same theme and enriches the research findings. Following the same path as the research, the qualitative method will first be addressed to, and various tools used in this approach will be explained. Then, the quantitative approach and its methods used are discussed.

Qualitative Approach

Data collection methods

The starting point of the project was primarily based on an in-depth literature analysis, during which a vast array of raw data from various sources were systematically collected, such as books, articles, websites, and doctoral theses. In addition, interviews were conducted aimed at precisely delineating the research approach.

➤ **Literary analysis:** In this study, a literary analysis was conducted, defined as an approach aimed at gathering pre-existing data on the subject or issue under investigation (Gaspard, 2018). The objective was to explore and analyze existing works, theories, concepts, and perspectives that are related to our research domain.

➤ **Interviews:** As an empirical starting point, a qualitative study was conducted through semi-structured interviews to define our approach. The interviews were conducted with four (4) quality managers from the company involved in the Cost of Quality management project. The purpose of these interviews was to understand the reasons for including the evaluation of the Cost of Quality, as well as broader perspectives and goals in this initiative. An interview guide was developed, organized into four distinct parts. Table 2 summarizes the main sections of the interview guide.

Table 2. Structure of the Interview Guide

Interview Guide		Number of Questions
Axis 1	Interviewee profiles	1
Axis 2	General context	2
Axis 3	Cost of Quality Management	6
Axis 4	Recommendations	2

Source: Compiled by the authors based on Interview Guide

Qualitative data analysis

Processing qualitative data is a pivotal step in any qualitative research, as it enables in-depth analysis of the phenomena or behaviors under study to derive meaningful conclusions. Qualitative data processing can be carried out manually or with the assistance of specialized software. Computer programs like Nvivo are extremely valuable tools for qualitative data processing.

This tool is indeed utilized for the analysis of the interviews. This software is specifically designed to support qualitative and mixed research methods by facilitating the collection, organization, and content analysis of diverse data sources such as interviews, focus group discussions, audio and video recordings, social media, and web pages, among others.

Quantitative Approach

Data collection methods

Quantitative research relies on the analysis of numerical data, which can be derived either from an empirical survey conducted by the researcher (primary data) or from an existing database (secondary data) (Judicaël et al., 2021). For this study, existing data was used and extracted from the GEDISO database of the company, which is a specific computer system for the HASANAQUI Group dedicated to overall business management.

The company’s data are analysed to apply Ferrebœuf’s model and make it relevant to the company’s context. However, some data were unavailable. To address this issue, new procedures were proposed and implemented to retrieve them, such as using awareness briefing records.

Treatment of quantitative data

In a quantitative study, processing quantitative data involves creating an appropriate electronic database to manage various types of data such as multiple responses, numerical data, and visual analog scale data. This approach entails the use of statistical techniques to understand the relationships between variables. Statistical software such as R, SPSS, and STATA are commonly employed for quantitative data analysis (Alison & Riris Andono, 2018).

In this study, given that the data are secondary data, the collected data are directly organized and processed to use them in the chosen model. Excel software is used to facilitate the calculation of mathematical formulas in their model. This allowed to analyze the data efficiently and present the results in a clear and concise manner.

Empirical Study

Due to the crucial importance of managing the costs associated with obtaining quality and their impact on overall business performance improvement, this approach was demonstrated using data from MDM. A quality cost management system was implemented using the algorithm proposed by Velkoska et al. (2018). The system is based on the cost of quality calculation model developed by Ferrebœuf (2000). This model details the various costs of each category and provides corresponding mathematical formulas for their calculation. It aligns with the Prevention-Appraisal-Failure (PAF) model guidelines, recognized for its effectiveness in quality cost management. The use of this model provides a clear and precise view of quality-related costs, thereby facilitating decision-making and the implementation of appropriate improvement measures. Table 3 represents the stages of practical application of our study adapted from Velkoska et al. (2018) algorithm and the methods used at each stage.

Table 3. Implementation Process of the Quality Cost Management System

Phases of the Velkoska et al. (2018) algorithm	Methods adopted to perform each phase
Phase 1 Framing the cost measurement system	Semi-structured interview: Framing the study based on the objectives and expectations of the company's top executives.
Phase 2 Cost measurement protocol	Adaptation of Ferrebœuf's model (2000) and designing a model suitable for the company's context. Calculating the Cost of Quality according to the mathematical formulas proposed by Ferrebœuf (2000) using Excel software.
Phase 3 Making decisions and implementing actions	Ishikawa: Identifying potential causes of unfavorable costs due to failures through the Ishikawa diagram method using MINITAB 17 software. FMEA: Identifying the consequences of failures and evaluating their criticality to prioritize them. Subsequently, corrective measures were proposed to prevent these failures

Source: Compiled by the authors based on algorithm of Velkoska et al. (2017)

The implementation process outlined in Table 3 demonstrates a structured approach to managing quality costs at MDM. In Phase 1, semi-structured interviews with top executives ensured that the cost measurement system was aligned with the company's strategic objectives. This step was crucial for gaining executive buy-in and setting a clear direction for the project. Phase 2 involved adapting the Ferrebœuf model to the specific context of MDM. By calculating the Cost of Quality using Excel software, the company was able to obtain a detailed breakdown of quality-related costs.

This quantitative analysis provided a solid foundation for identifying areas where cost savings could be achieved and where investments in quality improvement were most needed. In Phase 3, the Ishikawa method was employed to identify potential causes of unfavorable costs. This cause-and-effect analysis, facilitated by MINITAB 17 software, helped pinpoint.

RESULTS

Qualitative Results

After transcribing the interviews, an analysis of the responses was conducted using NVIVO software. This analysis aims to synthesize the answers and extract conclusions to be used in the study. To facilitate the analysis, the questions were grouped into themes, which were classified into two parts:

➤ The first part of the interview aimed to understand the quality approach within the company by addressing two aspects:

Quality for the company

Figure 1 presents a word cloud reflecting the quality within the company based on the statements of the interviewed individuals. Quality is essential in this company, as it is directly linked to customer satisfaction, brand image, and the reputation of the group to which it belongs. The quality objectives of the company are defined in its quality policy and can be measured through indicators such as product certification, traceability, reduction of non-conformities, and decrease in complaints.



Figure 1. Word Cloud Representing the Relevance of Quality for the Company That Was Created Using NVIVO Software, Based on the Results of Semi-Structured Interviews with Managers of a Woodwork Company

Source: Compiled by the authors based on the interview responses

Quality-related failures within the company

Figure 2 presents a word cloud representing defects and failures in terms of quality within the company, based on their frequency in the responses. It can be observed that the company faces five main failures: a high rate of rejects, a high rate of rejections, production process interruptions, delivery delays, and customer complaints. Other obstacles have also been identified, such as non-compliant raw materials, low involvement of process drivers, delays in the implementation of corrective actions, and immaturity of the quality culture.



Figure 2. Word Cloud of Quality Defects and Failures Within the Company That Was Created Using NVIVO Software, Based on the Results of Semi-Structured Interviews with Managers of a Woodwork Company

Source: Compiled by the authors based on the interview responses

➤ In the second part of the interviews dedicated to the management of the cost of quality, the aspects and questions of this part were grouped into three key themes:

Current state of the cost of quality management within the company

The respondents' answers reveal an inconsistent management of costs related to quality within the company. As shown in Figure 3, according to the interviewees, only costs associated with non-quality, such as scrap, complaints, and failures, are considered. However, these costs are evaluated solely in terms of quantity and are not accurately measured in terms of costs. Furthermore, they are included in the budget forecast.



Figure 3. Word Cloud of the Current State of the Cost of Quality Management Within the Company That Was Created Using NVIVO Software, Based on the Results of Semi-structured Interviews with Managers of a Woodwork Company

Source: Compiled by the authors based on the interview responses

Implementation of Cost of Quality management within the company

This section addresses two questions aimed at framing the implementation of Cost of Quality management: the reasons for emphasizing Cost of Quality management and the expectations following its implementation. The decision to prioritize Cost of Quality management was made to enhance the company's competitiveness, minimize costs associated with failures, improve customer satisfaction, and ensure overall company performance. Based on the responses obtained (shown in Figure 4), the expectations following this implementation are to focus efforts on weaknesses, minimize product costs, improve customer satisfaction, increase productivity, strengthen the brand image, and enhance product quality to ensure customer satisfaction.



Figure 4. Word Cloud of Cost of Quality Management Within the Company That Was Created Using NVIVO Software, Based on the Results of Semi-Structured Interviews with Managers of a Woodwork Company

Source: Compiled by the authors based on the interview responses

Recommendations for employee involvement and improving the management of the Cost of Quality

According to the interviewees, training and awareness sessions are key to employee engagement as demonstrated in Figure 5. Additionally, setting goals and key performance indicators for each stage of the process is also essential for improving the management of the Cost of Quality.



Figure 5. Word Cloud of Recommendations for Employee Involvement and Improving the Management of the Cost of Quality That Was Created Using NVIVO Software, Based on the Results of Semi-Structured Interviews with Managers of a Woodwork Company

Source: Compiled by the authors based on the interview responses

Quantitative Results

- Firstly, Ferrebœuf's model (2000) is segmented into 5 processes (Quality, Production, Maintenance, Commercial) using specific parameters for each process to enhance visibility and traceability.
- For prevention and detection costs, as well as external failures, Ferrebœuf's model (2000) is followed adapted to the company's context. Subsequently, the corresponding costs for these categories are calculated.
- Next, a specific model for internal failure costs (CDI) was developed. It tailored to the company's context. MDM has production lines, and each line is equipped with specific machines. The cost for each machine is calculated to produce a part and then estimated the costs of rework (modified products due to detected non-conformities) and scrap (non-conforming products that cannot be salvaged). This allowed to assess the costs of internal failures within the company.

Figure 6 below presents the detailed model for calculating the costs of internal failures at MDM.

Cost of each Machine	=	(Hourly cost per minute (S))* (Production time per minute (T)) + Raw material cost (MP)
Rejection Cost	=	Cost of producing a part + Cost of modifications made
Scrap Cost	=	Production cost of a part of the machine concerned * Quantity of scrap

Figure 6. Model for Calculating the Costs of Internal Failures at MDM

Source: Compiled by the authors based on data collected during the internship at MDM

The detailed model in Figure 6 illustrates how we calculated the costs associated with internal failures across the production lines of MDM. By breaking down the costs into key components such as machine hourly rate, production time, raw material costs, rework, and scrap, the company could accurately quantify the financial impact of quality issues and non-conformities. MDM could make more informed decisions to enhance operational efficiency and profitability with this granular understanding of internal failure expenses.

Calculation of Cost of Quality

After analyzing the data and adapting the model, the calculation of costs in accordance with Ferrebœuf’s (2000) mathematical formulas was performed as shown in Table 4.

Table 4. Costs of MDM Quality (the Costs are Measured in DA, the Monetary Unit of Algeria)

	Costs of each category per month				Total costs per month
	CP	CD	CDI	CDE	CP+CD+CDI+CDE
January	3 544 400,88	9 452 897,97	4154915,29	366969,9977	17 208 685,72
February	2 778 895,41	9 452 897,97	3368740,87	104619,2582	17 372 029,46
March	2 197 343,49	9 452 897,97	2251969,97	93689,41602	12 909 694,73
Category total for 3 months	8 520 639,79	28 358 693,90	10327824,75	283251,478	47 90 409,91

Note: CP: Prevention costs; CD: detection costs; CDI: internal failure costs; CDE: external failure costs; DA: dinar

Source: Compiled by the authors based on data collected during the internship at MDM

These costs are calculated to assess the effectiveness of prevention and detection measures by computing the non-quality cost rate and determining the production process performance in terms of quality, by calculating the percentage of internal failure costs relative to production costs.

Evaluation of Performance in Terms of Quality

Evaluation of the effectiveness of prevention and detection measures

Once the costs have been calculated and obtained, the effectiveness of prevention and detection measures is evaluated by calculating the rate of cost of non-quality. This rate is determined by comparing the costs of prevention and detection to the costs of internal and external failures. This evaluation provides a quantifiable measure of the effectiveness of the measures implemented to prevent quality problems and detect failures. As part of this evaluation, the company has established a tolerance threshold of 25% for the cost of non-quality rate. This threshold represents the acceptable level of financial losses related to the non-quality of products or services provided by the company. The results obtained from the calculation of this rate are represented in Figure 7:

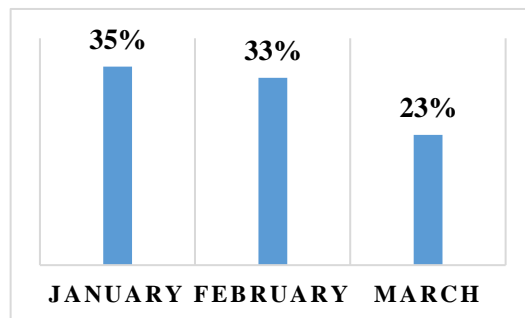


Figure 7. Cost of Non-Quality Rate

Source: Compiled by the authors based on data collected during the internship at MDM

According to Figure 7 depicting the rates of costs related to non-quality, these costs exceeded the threshold set by the company during the months of January and February, reaching 35% and 33% respectively. However, a significant improvement was observed in March, with a non-quality rate of 23%.

Evaluation of the effectiveness of prevention and detection measures

To evaluate the performance of the production process in terms of quality, another indicator is used. This is the percentage of internal failure costs compared to the total production costs. This ratio helps identify the proportion of costs related to internal failures in relation to the total costs incurred in production. The company has set a performance objective by establishing a threshold of 5% for this ratio. This threshold represents the desired level of financial losses specifically related to internal failures in the production process.

Figure 8 illustrates the results obtained the calculation of this rate.

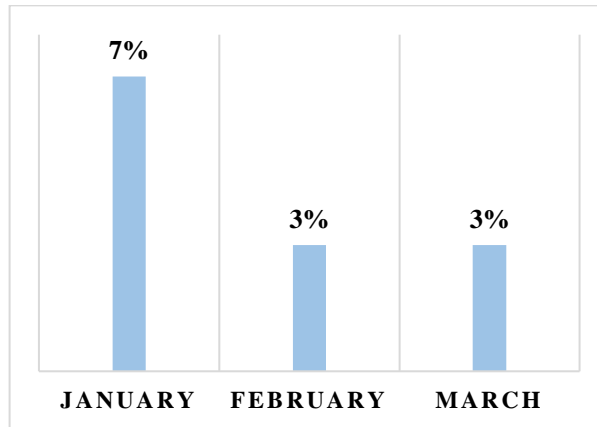


Figure 8. Internal Failure Rate

Source: Compiled by the authors based on data collected during the internship at MDM

In January, the company exceeded the threshold by 7%. However, a significant improvement in February and March is observed, with rates of only 3%, which represents a clear decrease compared to the previous month.

Results of the Analysis of Internal and External Failures of the MDM

To achieve the objectives and ensure that these rates remain below the established threshold, additional efforts will be necessary. To this end, an analysis of causes using the Ishikawa method for the five failures identified during the interviews. A corrective action plan was proposed to address these issues and the results are outlined in Appendix A. Table 5 introduces the Severity (S) and Frequency (F) scale, which measures the impact and occurrence rates of specific events or factors.

Table 5. Severity (S) and Frequency (F) Scale

Severity	Frequency
(4) Very Severe	4=Frequent
(3) Serious	3=Probable
(2) Moderate	2=Rare
(1) No Effect	1=Improbable

Source: Internal documents of GSH, 2017 (Hasnaoui Group of Companies)

Table 6. Criticality Matrix

Criticality	Classification
>=10	Critical
<=9	Major
<=6	Minor
<4	Not significant

Source: Internal documents of GSH, 2017

Table 6 presents the Criticality Matrix, which evaluates and prioritizes various elements based on their importance and impact. The FMEA method was applied to assess the criticality of the failures and determine their consequences, using the company’s matrix evaluation (see Table 5 and Table 6).

CONCLUSIONS

Quality and costs are closely intertwined, making the management of quality-related expenses an essential element of any organizational quality approach aimed at enhancing performance. This study underscores the importance of managing costs associated with quality and its profound implications for enhancing company performance. Over time, management of Costs of Quality (COQ) has become essential in many companies, functioning as an integrated system for information, control, and decision-making across a broad range of tasks. Initially focused on operational management, COQ is now integral to strategic decision-making and is reflected in management accounting practices.

The effectiveness of implementing a COQ management program was demonstrated by Alglawe et al. (2017), resulting in a 23% reduction in costs of quality for the organization. However, it is regrettable that the ISO 9000 series of standards has not yet integrated this practice into its guidelines, as emphasized by Ayach et al. (2019). Incorporating this measurement would significantly enhance awareness of quality-related practices and support their implementation within organizations.

This study employed a mixed-methods approach, combining qualitative and quantitative analysis to comprehensively examine the subject matter. In the qualitative phase, we conducted interviews to frame the research, align it with the company's objectives and expectations, and identify its failures. The results were analyzed using NVivo software, grouping interview responses into themes. The first part of the interview examines the importance of quality within the company, indicating that the company places crucial importance on quality to ensure customer satisfaction, enhance the brand image, and improve the group's reputation. The second part focuses on the company's quality failures, highlighting main defects and failures such as high rejection and scrap rates, production stoppages, delivery delays, and customer complaints, which can significantly impact customer satisfaction, productivity, and reputation. The third part assesses the current state of quality-related cost management, revealing inconsistencies. The cost of quality management is implemented, emphasizing reasons for this approach, significant expenses related to quality, and associated expectations. Recommendations to promote employee engagement and improve the cost of quality management are provided, emphasizing the importance of training, awareness sessions, and defining goals and key performance indicators.

Quantitative study results highlight a significant improvement in performance. The costs associated with internal and external failures were compared to investments in preventing and detecting quality problems. This ratio analysis shows a clear improvement, indicating a significant reduction in costs related to failures compared to investments made to prevent and detect these problems. This improvement reflects better control of production processes, evidenced by reduced internal failure rates and decreased quality incidents, demonstrating the company's commitment to continuous improvement of its quality performance.

This study highlights the importance of managing costs of quality and their impact on company performance. Elucidating the relationship between quality and costs equips organizations with tools for informed decision-making and performance enhancement. Given that quality-related expenses constitute a significant portion of a company's revenue, conducting financial analysis in quality improvement initiatives is imperative to quantify failure costs, identify quality-related issues, and enhance overall performance.

In summary, integrating cost management principles into all aspects of quality improvement initiatives is crucial. Recognizing the link between quality and costs and proactively managing these expenditures enables organizations to achieve sustained competitive advantage and foster a culture of continuous improvement. Therefore, embracing the measurement of Costs of Quality as a cornerstone of quality management programs is imperative for organizations striving for excellence.

Moving forward, several avenues for further research in managing costs of quality and its implications for organizational performance remain. Future studies could delve deeper into specific methodologies and frameworks utilized by companies to implement cost of quality management programs successfully. Understanding best practices and strategies across various industries could provide valuable insights for optimizing quality-related expenses.

Moreover, exploring the long-term effects of implementing cost-of-quality management programs on various aspects of organizational performance, such as profitability, customer satisfaction, and employee morale, can offer a comprehensive understanding of the overall impact. A longitudinal approach would enable researchers to assess the sustainability and scalability of such initiatives over time. Additionally, research is needed to integrate cost management principles into existing quality management frameworks, such as the ISO 9000 series of standards. Investigating the feasibility and challenges of incorporating cost of quality measurement into these established guidelines would facilitate broader adoption and standardization across industries. Considering the evolving nature of industries and the increasing emphasis on sustainability and

social responsibility, future research could explore the intersection of cost of quality management with environmental and ethical considerations. Understanding how organizations can balance quality-related expenses with broader societal concerns is pertinent in today's dynamic business landscape. Further research in this area has the potential to enrich our understanding of the relationship between quality and costs, providing practical insights for organizations seeking to enhance their performance and competitiveness in an ever-changing market environment.

Author Contributions

Conceptualization: C. B., L. N., N. H., M. A.; methodology: N. H.; project administration: N. H.; software: N. H., W. B.; validation: N. H., M. B., W. B.; formal analysis: N. H.; investigation: C. B.; resources: N. H.; data curation: C. B., L. N.; writing-original draft preparation: N. H., C. B., L. N., M. A.; writing-review and editing: N. H., M. B., W. B., M. A., L. N.; visualization: M. B., C. B.; supervision: M. B., W. B., M. A.; funding acquisition: N. H.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

Not applicable.

Informed Consent Statement

Not applicable.

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Appendix A

Table A1. Combined FMEA (Failure Mode and Effects Analysis) Method with Ishikawa Method

Failure	Causes: classified according to the Ishikawa method						Consequences	Criticality			Action plan	
	Manpower	Materials	Methods	Equipment	Environment	Management		S	F	C		
Delivery Delay	<ul style="list-style-type: none"> -Lack of Training -Lack of Experience -Workload Non-compliance with work procedures -Lack of adequate supervision -Lack of technical skills to perform the job correctly -Poor attitude towards work 	<ul style="list-style-type: none"> -Poor quality of raw materials -Inadequate storage and handling of raw materials 	<ul style="list-style-type: none"> -Non-compliance with production practices -Inefficient measurement and inspection methods -Inadequate working method -Insufficient control -Insufficient or inadequate quality control -Failure to follow good production practices -Measurement or testing errors -Poor production planning -Inappropriate use of tools and equipment 	<ul style="list-style-type: none"> -Incorrect machine settings -Obsolete or defective production equipment -Defective machines and equipment Poor machine installation -Insufficient or inadequate machine maintenance -Incorrect machine calibration 	<ul style="list-style-type: none"> -Cleanliness and hygiene of the work environment -Uncomfortable work environment 	<ul style="list-style-type: none"> -Insufficient communication -Non-compliance with quality specifications -Non-compliance with quality specifications -Lack of standardized procedures for implementation processes 	<ul style="list-style-type: none"> -Higher production costs due to wasted resources (raw materials, labor, etc.). -Decreased yields and productivity. -Loss of profitability. -Raw material shortages. -Delays in delivering finished products to customers. -Extra costs of non-quality in terms of rework, repairs, replacements, modifications, etc. 	4	3	12	Critical	<ul style="list-style-type: none"> -Setting up standardized procedures and operating modes to ensure process standardization. -Implementing a regular training and awareness program for workers and supervisors to acquire the necessary technical skills to perform their work correctly. -Enhancing operators' awareness of machine and equipment preservation. -Implementing strict production procedures to prevent human errors and machine adjustment issues. -Establishing an effective communication system to avoid process errors.
Customer Complaints	<ul style="list-style-type: none"> -Personnel absenteeism. -Lack of motivation or participation. 	<ul style="list-style-type: none"> Unavailability of Raw Materials 	<ul style="list-style-type: none"> Lack of task planning or coordination. 	<ul style="list-style-type: none"> -Old machines -Equipment failure -Inadequate maintenance or repair -Ineffective preventive maintenance 	<ul style="list-style-type: none"> -High security risks -Serious occupational accidents 	<ul style="list-style-type: none"> -Poor management and inadequate organization of processes -Poor communication 	<ul style="list-style-type: none"> -Loss of revenue due to production interruption. -Extra costs associated with corrective maintenance. -Delays in delivering finished products to customers. 	3	3	9	Major	<ul style="list-style-type: none"> -Identify the skills and training needs of the staff and develop a training plan to enhance their skills. -Strengthen coordination and communication between production, quality control, and maintenance. -Regularly assess and update the tools and techniques used to ensure they are adequate and up to date. -Improve the regular preventive maintenance program to prevent equipment failures. -Implement the Total Productive Maintenance (TPM) approach. -Ensure the availability of raw materials by improving inventory management.

Table A1 (cont.). Combined FMEA (Failure Mode and Effects Analysis) Method with Ishikawa Method

Failure	Causes: classified according to the Ishikawa method						Consequences	Criticality			Action plan
	Manpower	Materials	Methods	Equipment	Environment	Management		S	F	C	
Delivery Delay	<ul style="list-style-type: none"> -Processing errors for orders -Frequent absences 	<ul style="list-style-type: none"> -Unavailability of Raw Materials -Quality issues with raw materials that delay the production process. 	<ul style="list-style-type: none"> -Commands outside the schedule -Poorly monitored production program -Coordination problems among the different parties involved in the delivery process -Gaps in order tracking and management systems 	<ul style="list-style-type: none"> -Defective equipment -Unresolved maintenance issues -Outdated or unsuitable machines that cannot keep up with production demand -Frequent breakdowns of machines used in the production process -Unavailability of trucks 		<ul style="list-style-type: none"> -Poor planning -Ineffective resource management -Lack of communication between different parts of the production process -Absence of effective leadership -Changes to production schedules 	<ul style="list-style-type: none"> -Customer dissatisfaction -Loss of customers and damage to customer loyalty -Risk of contractual penalties -Payment delays 	3	3	9	Major <ul style="list-style-type: none"> -Ensure compliance with the production schedule by avoiding placing orders outside the program, especially if it could lead to obstacles. -Regularly carry out inspections and preventive maintenance to prevent equipment breakdowns. -Expand the portfolio of transport suppliers. -Establish effective resource planning and management to avoid delays caused by improper resource allocation. -Implement an employee motivation system.
Customer Complaints	<ul style="list-style-type: none"> -Lack of involvement from operators and quality control agents -Order processing error -Poor behavior of installers 	<ul style="list-style-type: none"> -Products or services do not meet customer requirements. -Damaged products. 	<ul style="list-style-type: none"> -Delivery delay -Errors in order delivery (delivery of incomplete orders) 	<ul style="list-style-type: none"> -Poor choice of truck -Inadequate handling (supplier docks, customer docks) 	Poor customer care	<ul style="list-style-type: none"> -The company's policies and practices do not meet customer expectations. -Poor management of customer relationships. -The company lacks a clear strategy to improve the customer experience or maintain a positive image with customers. 	<ul style="list-style-type: none"> -Decrease in turnover and profitability. -Deterioration of the company's reputation and renew. -Distrust from other clients and partners. -Increased difficulty in acquiring new clients. -Loss of the customer. 	3	2	6	Minor <ul style="list-style-type: none"> -Request regular feedback from customers to improve communication. -Conduct market research to better understand customer needs and expectations. -Perform product testing to ensure compliance with quality and safety standards. -Optimize the delivery and logistics process to reduce waiting times. -Communicate with customers about any potential delivery delays. -Take into account customer feedback to improve policies and practices. -Offer refunds or exchanges for unsatisfactory products or services. -Streamline the production process to reduce waiting times.

Source: Compiled by the authors based on data collected during the internship at MDM