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EVALUATING QUALITY COST MANAGEMENT SYSTEMS IN MOROCCO'S CHEMICAL AND PARA-CHEMICAL LANDSCAPE: A COMPREHENSIVE ANALYSIS

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Abstract:
This paper investigates quality management practices within the chemical and para-chemical industry, focusing on survey responses from 175 Moroccan industrial companies. Findings reveal a significant adoption of Quality Management Systems (QMS), with 82% of companies implementing ISO 9001 V15 certification. Analysis of QMS maturity levels highlights varying degrees of sophistication in quality management practices, with a majority of organizations concentrated on Certainty and Enlightenment levels. Additionally, companies exhibit diverse perspectives on the cost of quality, with implications for preventive measures and leadership involvement. While 51% of respondents are unfamiliar with Quality Cost Management Systems (QCMS), 78% express interest in training initiatives. Obstacles to QCMS implementation include top management commitment and data collection difficulties. Furthermore, a comparative analysis of quality costs across subsectors underscores variations and trends within the industry. The paper concludes with recommendations for reducing quality costs and enhancing overall quality management practices, aiming to inform industry stakeholders and researchers alike.

Key words: Quality Cost Management Systems (QCMS), Moroccan chemical and para-chemical industry, Quality Management Systems (QMS)

INTRODUCTION

Quality management is an indispensable component of contemporary organizational strategies, permeating industries and organizational scales alike [1]. The integration of quality principles throughout operational frameworks ensures a comprehensive evaluation of quality requisites along the production continuum. However, in tandem with quality considerations, there is a growing emphasis on the analysis of associated costs within the contemporary business landscape [2]. This necessitates a meticulous examination of quality costs, facilitating intra-organizational communication and guiding strategic decisions rooted in financial imperatives [3]. Consequently, the ascendancy of Quality Cost Management Systems (QCMS) becomes increasingly evident, legitimizing quality-centric approaches by highlighting their inherent profitability [4].

Embedded within the foundational pillars of quality management systems are the costs of conformance and non-conformance, which have garnered widespread international adoption, showcasing demonstrable profitability and efficacy [5, 6]. Despite the progress in the extant literature, a notable gap persists, particularly concerning insights at the national level within the Moroccan industrial context, where the recognition and implementation of such systems remain suboptimal [7].

To address this gap, this article undertakes a comprehensive examination of the challenges surrounding quality cost management systems within the Moroccan chemical and para-chemical industries [8]. Central to this endeavor are overarching inquiries that delve into the level of awareness, the extent of implementation, and inherent obstacles encountered by industrial enterprises. The focus on the chemical and para-chemical sectors within the Moroccan job market is imperative, given its contribution to the national industrial landscape [9, 10].

The structure of this article is designed to elucidate the theoretical and contextual underpinnings of QCMS, delineate the methodological frameworks underpinning our study, and analyze empirical insights garnered through meticulous inquiry. By addressing these dimensions, this paper seeks to contribute to the enhancement of quality management practices within the Moroccan chemical and para-chemical industries, thereby fostering sustainable growth and competitiveness in alignment with stringent standards and regulatory requirements.

Through a structured approach encompassing industry insights, challenges, and strategies for improvement, this

paper aims to offer valuable insights and practical recommendations for industry practitioners, policymakers, and researchers invested in advancing quality management practices within the chemical and para-chemical sectors.

LITERATURE REVIEW

Theoretical framework: Definition of quality costs

The "quality cost" (QC) is a concept that first appeared in 1951 with Juran Joseph in his book "Quality Control Handbook". The concept has gone by several names, such as the cost of obtaining quality, the cost of non-quality or even the cost of imperfection [11]. This cost has been defined as the sum of costs that can be estimated, such as the profit not earned as a result of non-conformity. It is the investment that an organization must make to increase its sales while maintaining the quality of the products or services it markets [12].

QC is calculated as the sum of the costs of quality "CQ" and the costs of non-quality "CNQ". Quality costs include the expenses incurred to ensure quality through control and prevention. Non-quality costs measure the costs of internal and external failures and malfunctions [13].

Measuring COQ is a crucial issue for any quality manager who wants to remain competitive in a highly dynamic market [14]. This tool enables us to understand the relationship between costs due to malfunctions and those invested in ensuring quality. This will justify the return on investment of the quality approach and implicitly enable quality managers to speak the same language as the top management: "a financial language" [15].

Quality Management Systems vs Quality Cost Management Systems

Quality Management Systems (QMS) encompass the framework and processes for managing and enhancing quality, focusing on meeting customer requirements and improving business performance [16, 17]. On the other hand, Quality Cost Management Systems (QCMS) specifically target controlling costs related to quality issues throughout the product/service lifecycle, aiming to minimize expenses while maximizing quality and customer satisfaction [18]. QMS standards like ISO 9001 provide a structured approach for organizations to establish and maintain their quality management systems, while QCMS helps track and manage costs related to quality, including prevention, appraisal, internal failure, and external failure costs [19]. Both QMS and QCMS are crucial for organizations to consistently deliver high-quality products or services efficiently and effectively, with QMS focusing on overall quality management and QCMS addressing the financial aspects of quality management.

Previous studies on quality costs in industrial sectors

International level: Studies and surveys

An examination of extant literature unveils a multifaceted exploration of quality costs within industrial sectors, spanning diverse methodologies and global perspectives. Previous studies on quality costs in industrial sectors have been diverse and widespread, encompassing various methodologies and geographic locations. Tigor Tambunan's research emphasized the application of the quality cost concept within the Strategic Cost Management (SCM) framework, proposing practical implementations [20]. Similarly, a study conducted in Iraq investigated the influence of quality cost management on internal control effectiveness within industrial companies, highlighting its significance in organizational governance [21].

Warcito and Nengzih delved into the analysis of quality costs attributable to defective products, particularly examining its ramifications on company performance within the bottled drinking water industry, shedding light on sector-specific challenges [22]. Al-Ghazali and Hazim explored the intricate relationship between quality cost systems and pricing decision-making processes within industrial settings, underscoring the economic implications of quality management decisions [23].

Moreover, survey-based studies have provided valuable insights into the prevalence and understanding of quality costs across different industrial landscapes. For instance, Bris et al.'s survey of manufacturing companies in the Czech Republic revealed that a substantial majority, 73% of organizations, actively quantify their quality costs, indicating a widespread acknowledgement of its importance [24]. Velkoska and Tomov's empirical research in the automotive manufacturing sector identified significant elements contributing to quality costs, aiding in the delineation of cost structures and resource allocation strategies [20].

Furthermore, Tambunan's continued focus on integrating the quality cost concept into strategic frameworks, such as the Quality Cost Chain model, underscores ongoing efforts to refine management approaches and optimize cost-control mechanisms [25]. Similarly, studies conducted in Iraqi industrial companies and other contexts have emphasized the importance of adopting integrated approaches to quality cost analysis, offering practical recommendations for enhancing organizational efficiency and competitiveness [21, 22]. Collectively, these studies contribute to a comprehensive understanding of quality costs and their management across diverse industrial sectors, providing valuable insights for practitioners and researchers alike.

National level: Empirical studies on QC in Morocco

Empirical surveys of quality cost management systems are widespread internationally. Following these surveys, the authors expressed great disappointment at the small number of companies with a QCMS. Even the minority of companies that do adopt such systems don't integrate them into strategic decision-making or opportunities for improvement.

While on a national scale, Empirical studies on quality cost in Morocco are limited, with few studies conducted in the country. The first QC survey was only conducted in 2018 and targeted all sectors of manufacturing companies. This survey was administered by Dr Ayach Lamiaa on a sample of 234 based on 65505 companies. The author had three main aims for this questionnaire:

- Identify the application's level of quality cost management in Moroccan industrial companies;
- Analyze the practices of Moroccan industries in quality cost management and understand the obstacles to the implementation of a QCMS;
- Analyze the correlation between an organization's characteristics and the implementation/sophistication of a QCMS.

Organizations responding to the questionnaire came from 13 different industry sectors. The highest response rate came from the automotive and machinery industry (24.8%), followed by the food and beverage industry at 23.1%. This was followed by 15% from the chemical industry.

Although 76.9% of respondents declared that it is important to control quality costs, only 35.5% of them have implemented a QCMS, the majority of which is based on a process model with a monthly calculation communicated exclusively to the top management and/or the quality department [26].

As the rate of QCMS implementation was too low, the author went on to understand the obstacles preventing manufacturers from doing so. The main reasons and their percentages were as follows:

- Complexity of implementing a QCMS: 40.5
- Lack of knowledge of QC elements: 21.1
- Difficulties in collecting data: 10.9
- Inadequate budget: 9.9
- Uncooperative Employees: 8.6
- Lack of interest in implementing QC, given that the current system is capable of identifying effective areas for quality improvement: 5.3
- Insufficient staff: 3.9

Following those obstacles, it was vital to find out what techniques quality managers used to prioritize their improvement activities. Indeed, the majority of quality managers without a QCMS affirmed that they use performance indicators (KPIs) to prioritize improvement activities. Others stated that the previous year's quality expenditure is the main reference for drawing up an improvement plan and estimating the quality department's budget.

Based on this study, it was recommended that quality costs be analyzed by sector. The aim is to study the specific features of each sector.

Relevance of quality costs to the chemical and parachemical industries

The relevance of quality costs to the chemical and parachemical industries is paramount. As they have crucial aspects such as pricing decisions, revenue sharing within supply chains, and overall profitability. Quality cost systems serve as indispensable tools in providing essential data and information about risks, thereby enabling companies to make well-informed pricing decisions that can confer a competitive advantage [23]. Moreover, these systems influence the allocation of revenue-sharing proportions in supply chains, reflecting the significance of different quality cost categories in shaping collaborative arrangements [27].

In addition to informing pricing strategies and revenue sharing, quality cost systems play a pivotal role in identifying and addressing various factors contributing to quality-related costs within these industries. From machine downtime to wasted materials and customer dissatisfaction, these systems offer a proactive approach to mitigating potential profit losses stemming from quality issues [28, 29]. By facilitating the systematic analysis of cost contributors, companies can implement targeted measures to optimize processes, minimize waste, and enhance overall operational efficiency.

Furthermore, effective management of quality costs is essential for sustaining high-quality production standards and achieving organizational goals. Controlling quality costs not only ensures the consistency of product quality but also fosters customer satisfaction and loyalty, which are indispensable for long-term success [30]. The significance of quality cost management extends beyond financial performance to encompass environmental sustainability efforts. The introduction of management control systems aimed at reducing the cost of poor quality (CoPQ) aligns financial objectives with environmental stewardship, reflecting a holistic approach to business management [31].

Moreover, quality cost models such as the PAF model offer valuable insights into the internal value chain of chemical and parachemical industries. By analyzing the interplay between preventive, appraisal, and failure activities, companies can identify opportunities for cost reduction and profit optimization [20]. Such analyses provide a structured framework for continuous improvement initiatives, ensuring that resources are allocated efficiently and effectively across the value chain.

Therefore, the relevance of quality costs to the chemical and parachemical industries transcends mere financial considerations. It encompasses critical aspects of pricing decisions, revenue sharing, sustainability efforts, and overall profitability. Quality cost systems and models serve as indispensable tools in identifying cost contributors, optimizing processes, and driving continuous improvement, thereby underpinning the long-term success and competitiveness of these.

METHODOLOGY

Methodological approach for data collection

The methodological approach used in this paper for data collection is a questionnaire survey. The decision to conduct an online survey was primarily influenced by its cost-effectiveness, convenience, and ability to reach a wide audience efficiently. Online surveys provide economical access to participants online, making them a cost-effective option for data collection [32]. They also offer the advantage of reaching a larger pool of potential participants within a shorter period compared to face-to-face surveys [33]. Additionally, online surveys minimize logistical constraints associated with traditional methods such as in-person interviews, mail surveys, or postal surveys [34].

The use of digital platforms in contemporary business environments further supports the widespread use of online surveys for broader participation [35] and offers a convenient and efficient means of data collection [36].
The chosen methodological approach for this survey, encompassing both quantitative and qualitative elements, was driven by the need to obtain a comprehensive understanding of quality cost management practices in the chemical and para-chemical sector of Moroccan industrial companies. By combining quantitative analysis to determine the implementation rate of Quality Cost Management Systems (QCMS) with a qualitative inquiry into manufacturers' practices and perceived obstacles, the study aimed to offer a nuanced perspective on the subject matter.

Sampling technique and sample size

The sampling plan was meticulously designed to ensure the reliability and validity of the study results. By employing a stratified random sampling technique based on the population size of companies in the target sector, the research aimed to obtain a representative sample that accurately reflected the characteristics of the parent population. The choice of a 95% confidence level and a 5% margin of error underscored the commitment to achieving statistically robust outcomes. The sampling was carried out in 5 sub-steps, as shown below:

- Step 1: The first step was to research the size of the population "number of companies active in the chemical and para-chemical sector". This has a value of 1600, according to the article published in the daily newspaper on September 22, 2022.
- Step 2: The next step was to define the margin of error (e), also known as the confidence interval. This indicates how close the results of our sample are to the true value of the parent population. This interval (e) was set at 5%.
- Step 3: At this level, we had to choose a confidence level that allows us to measure the degree of certainty that our sample represents the population, based on the margin of error already defined. This variable is a percentage equal to 95%.
- Step 4: Determining the value of the standard deviation (p) was the 4th step. This parameter reflects the expected variation between different responses. Since this variable is difficult to determine before a survey is carried out, the majority of researchers set it at a value of 0.5 (50%). This value takes into account the worst-case scenario. By using this standard deviation, we can be more sure that the sample size is large enough to represent correctly our population.
- Step 5: Before proceeding with the calculation, we had to find the reduced centred variable (z). This defines the number of standard deviations between a given value and the mean of the parent population. The reduced-centred variable is automatically defined according to the confidence level. As this level has been set at 95%, the Z would be 1.96.
- Step 6: The final sub-step is to calculate the sample size according to the following formula:

$$\text{The sample size} = \frac{\frac{z^2 \cdot p(1-p)}{e^2}}{1+\left(\frac{z^2 \cdot p(1-p)}{e^2 N}\right)} \quad (1)$$

With a population size (N) of 1600, a score (z) of 1.96, an error margin (e) of 0.05, and a standard deviation (p) of 0.5."
The analysis indicated that a sample size of 310 individuals was required for the questionnaire.

Description of the survey design

The current survey was structured following the BOSS principle (Brief, Objective, Specific, Simple). It consisted of four main sections, commencing with an introduction outlining the research objective. Figure 1 illustrates the questionnaire's layout [37].

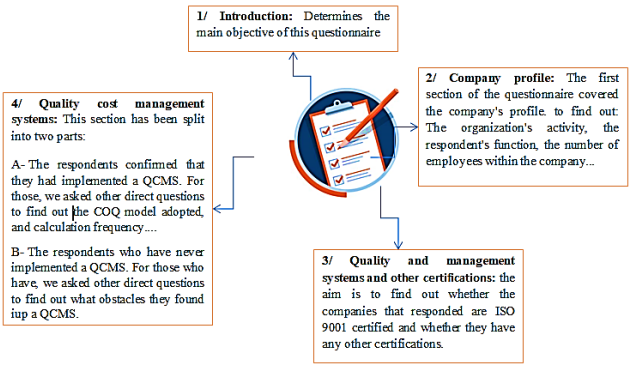


Fig. 1 Structuring the Survey: Key Sections of the Questionnaire

After finalizing the questionnaire, we proceed to a crucial stage before distribution: questionnaire testing. This step aims to identify any anomalies, ambiguities, or poorly formulated questions.
It was imperative that the testing involved individuals who were not involved in the survey's development to ensure an impartial evaluation. Consequently, the questionnaire was distributed to quality and HSE managers, consultants, technical directors, and general managers for this purpose.

Approaches for data processing and prioritization of Obstacles

Calculation of the percentages

The data processing, particularly concerning the calculation of percentages was carried out manually. The percentages reported in this paper, including those relating to the distribution of respondents by company size and employee numbers, were derived manually from the collected survey data. The general relation used to calculate percentages is:

$$\text{Percentage} = \frac{Part}{Whole} \cdot 100\%, \quad (2)$$

where:

- "*Part*" represents the specific subset or category of interest.
- "*Whole*" represents the total population or sample size.

This formula is applied to each subset or category to determine its percentage contribution relative to the total. By multiplying the ratio of the part to the whole by 100%, we obtained the percentage value.

Pareto diagram

Pareto analysis was employed in this study to identify the primary obstacles hindering the implementation of Quality Cost Management Systems (QCMS) [17] within the chemical and parachemical industries in Morocco [38]. Pareto analysis, a widely used technique in quality management, prioritizes issues based on their frequency and impact [39]. The analysis was conducted by compiling data obtained from respondents who were professionals and stakeholders within the industry [40]. By applying Pareto analysis, critical causes of failures in the management system can be identified. Which helps in problem-solving and continuous improvement by identifying the root cause of the problem and implementing corrective actions [41].

The survey instrument included a series of questions targeting various obstacles perceived by industry experts [42]. The responses were then tabulated and analyzed to determine the frequency and cumulative percentage of each obstacle. The mathematical relation for calculating cumulative percentage can be expressed as:

$$\text{Cumulative percentage} = \frac{\textit{Cumulative frequency of factor}}{\textit{Total Frequency}} \cdot 100, \quad (3)$$

where:

- *Cumulative Frequency of Factor*: The sum of frequencies up to and including the current factor,
- *Total Frequency*: The total sum of frequencies for all factors.

This calculation was performed for each factor to determine its cumulative percentage. Subsequently, the obstacles were ranked in descending order of importance based on their cumulative percentage contribution to the total responses.

RESULTS AND DISCUSSION

Overview of survey respondents

The survey aimed to gather insights from Moroccan industrial companies, particularly in the chemical and parachemical sectors. Out of the 1500 companies targeted for the survey, 175 completed responses were received, representing a response rate of approximately 11.7%. This lower percentage may indicate potential challenges in engaging companies for surveys in this industry. This could be attributed to various factors such as time constraints, competing priorities, or reluctance to participate in surveys. Despite this limitation, the 175 completed responses still provide valuable data for analysis, although with a slightly increased margin of error.

The respondents represented a diverse range of industries, encompassing 14 different sub-sectors. Interestingly, a significant majority, constituting 80% of the respondents, were concentrated within six specific sub-sectors: Manufacture of phosphoric acid and fertilizers/MDCP, Manufacture of artificial or synthetic fibers, Manufacture of soaps, cleaning products and perfumes, Cement factory, Ceramics factory, and Briquetry factory.

The concentration of respondents within specific sub-sectors suggests potential areas of focus or specialization within the industry. Notably, a significant proportion of respondents are engaged in manufacturing processes, particularly in industries related to chemicals, construction materials, and consumer goods. This may suggest that certain segments of the chemical and para-chemical sector may be more active or prominent, possibly indicating higher demand, technological advancements, or regulatory influences in these areas.

Regarding company size, the survey captured a diverse range of organizations, with 47.5% categorized as large firms (more than 250 employees). This distribution reflects the heterogeneous nature of the industry, encompassing both small-scale enterprises and large-scale corporations.

Additionally, the survey revealed that the majority of respondents (69%) were national companies, while 31% were multinational entities. Furthermore, 70% of companies operated solely onshore, highlighting the prevalence of domestic operations within the sector.

The following table 1 shows successively the size of the respondent organizations, and employees' number and the last column shows the percentage of these respondents.

Table 1
Distribution of respondent organizations by size and employee numbers

Companies size	Employees	Percentage
Micro firms	5-10	10%
Small firms	10-50	20.4%
Medium firms	50-250	22.1%
Large firms	More than 250	47.5%

Source: [43, 44, 45].

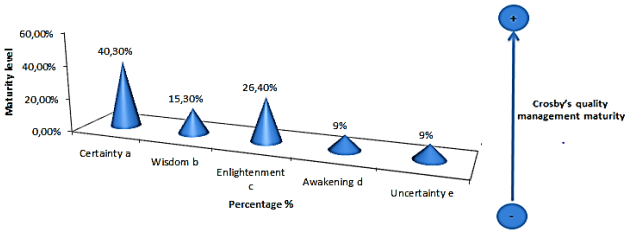
Analyzing the distribution of respondent organizations based on size and number of employees provides valuable insights. Micro firms, defined as those with 5-10 employees, comprised 10% of the respondents. Small firms, employing between 10 to 50 individuals, represented 20.4% of the sample. Medium-sized enterprises, with a workforce ranging from 50 to 250 employees, accounted for 22.1% of respondents. Notably, large firms, employing more than 250 individuals, constituted the largest segment, comprising 47.5% of the surveyed organizations.

Daniel Ruiz-Equihua et al. have related this pattern to the fact that smaller companies, especially small- and medium-sized enterprises (SMEs), tend to have lower response rates due to limited resources and time constraints [46]. On the other hand, Mojca, Bavdaž et al. noted in their study on achieving responses from fast-growing companies, specifically the case of Slovenian gazelles, that the larger corporations may receive a higher number of surveys and may find them burdensome, leading to selective participation or non-participation [47].

Analysis of Quality Management Systems in chemical and para-chemical Moroccan industry

The survey findings indicate a significant adoption of Quality Management Systems (QMS) within the chemical and para-chemical sector, with 82% of companies reporting implementation. Among these, a substantial portion (76%) had obtained ISO 9001 V15 certification, signifying a commitment to international quality standards.

Furthermore, the analysis of QMS maturity levels represented in Figure 2 provides an insightful analysis of the quality management maturity levels within the Moroccan chemical and para-chemical industry, utilizing Crosby's Quality Management Maturity Grid. This evaluation categorizes maturity into five distinct levels: Certainty, Wisdom, Enlightenment, Awakening, and Uncertainty, each representing varying degrees of sophistication in quality management practices and organizational mindset.



[a]*Quality is essential*; *problems are prevented*; *the cost of quality is reported as 2.5% (what it really is)*; *quality improvement is continual and normal*"; statement: *We know why we do not have problems with quality*.

[b]*Top management participation*; *problems are identified in earlier development*; *cost of quality is reported as 6.5% (actually it is 8%)*; *quality improvement program is continual*; statement: *defect prevention is a routine part of our operation*.

[c]*Quality is elevated to a functional level*; *problems are resolved openly and in an orderly way*"; *the cost of quality is reported as 8% (it is 12%, still underestimated)*; statement: *We are identifying and resolving our problems*.

[d]*The organization is not willing to commit resources, although quality management may be valuable*; *emphasis on appraisal and moving the product*; *there are no long-range solutions*; *the cost of quality is reported as 3% (actually it is 18%, hugely underestimated)*; statement: *why do we always have problems with quality?*

[e]*Problems are fought as they occur*; *the cost of quality is unknown*; *there are no organized quality improvement initiatives*; statement: *we don't know why we have problems with quality*.

Fig. 2 Evaluation of Quality Management Maturity Levels: Crosby's Quality Management Maturity Grid

Source: [48, 49, 50, 51].

At the highest maturity level, Certainty, comprising 40.3% of organizations, there is a strong recognition of the paramount importance of quality. Wisdom, encompassing 15.3% of organizations, denotes a stage where top management actively participates in quality management endeavors. Organizations at the Enlightenment level constituting 26.4% elevate quality to a functional level within their operations. Conversely, 9% for the Awakening level reflects organizations that exhibit hesitancy in committing resources to quality management initiatives. Finally, the Uncertainty level of 9% represents organizations grappling with reactive quality management practices.

The analysis shows that the majority of organizations are concentrated within the Certainty and Enlightenment levels, indicating a significant proportion have embraced quality management practices to varying extents. This suggests a positive trend towards recognizing the importance of quality, implementing preventive measures, and striving for continuous improvement. However, a notable finding across all maturity levels is the underestimation of the true costs of quality. This indicates potential gaps in cost estimation methodologies or a lack of awareness regarding the comprehensive expenses associated with quality management. Top management involvement emerges as a crucial factor, particularly in organizations classified under the Wisdom and Enlightenment levels. This underscores the significance of leadership commitment to driving quality initiatives and fostering a culture of quality throughout the organization. Strong leadership support is essential for prioritizing quality, allocating resources appropriately, and sustaining quality improvement efforts over the long term. On the other hand, organizations categorized under the Awakening and Uncertainty levels exhibit reactive approaches to quality management, with a focus on addressing issues as they arise rather than proactively preventing them. Shifting towards a proactive quality management mindset is crucial for enhancing operational efficiency, minimizing defects, and improving customer satisfaction. Continuous improvement remains an overarching goal for all organizations, regardless of their maturity level.

Among the companies interviewed, each had its definition of the cost of quality. These perspectives will be detailed in the following Table 2. The table therefore unveils a spectrum of perspectives on the cost of quality as discerned from interviews conducted with different companies. Through these discussions, it becomes evident that diverse interpretations exist regarding how organizations define and manage the expenses.

Table 2
Perspectives on the Cost of Quality: Insights from Company Interviews

Definition	Percentage (%)
The cost of non-quality, which must be evaluated and reduced in order to control production costs	44.57%
The cost of maintaining quality in industry, services or any other organization	31.43%
The sum of costs that can be estimated, such as the profit not earned due to non-conformity	14.86%
The losses incurred when quality is not achieved	9.14%

Source: [49, 50, 51, 52].

One prevalent viewpoint, subscribed to by 44.57% of the interviewed companies, revolves around the cost of non-quality. According to this perspective, controlling production costs hinges upon evaluating and mitigating expenses arising from defects, errors, and inefficiencies in the manufacturing or service delivery processes. This approach underscores the imperative of minimizing non-

conformities to optimize operational efficiency and resource utilization.

A substantial proportion of companies (31.43%) articulate the cost of quality as encompassing the expenditures required to uphold standards across industries, services, or any organizational setting. This broader interpretation highlights the ongoing investment needed to maintain quality assurance mechanisms, emphasizing its role as a fundamental aspect of business operations.

In contrast, a notable fraction of companies (14.86%) conceptualize the cost of quality as a quantifiable sum of estimable expenses, including potential profit losses attributable to non-conformity. This perspective underscores the tangible financial ramifications of quality lapses, stressing the significance of effective quality management practices in preserving revenue streams and sustaining competitiveness.

Conversely, a minority of companies (9.14%) view the cost of quality through the lens of losses incurred when quality standards are not met. This perspective accentuates the adverse consequences, immediate and long-term, stemming from failures to achieve desired levels of quality, thereby underscoring the importance of proactive quality control measures.

In sum, Table 2 elucidates the nuanced understanding of the cost of quality among companies, reflecting varying degrees of emphasis on aspects such as defect prevention, ongoing quality maintenance, financial implications, and risk mitigation. These divergent perspectives underscore the complexity of managing quality-related expenses and underscore the importance of tailored approaches to address the specific needs and priorities of individual organizations.

To get a clearer idea of how respondents perceive the QC, we asked them the following question: In your opinion, what elements are integrated into the QC? From their responses, we came up with four groups.

Figure 3 provides insights into respondents' perceptions regarding the elements integrated into Quality Control (QC).

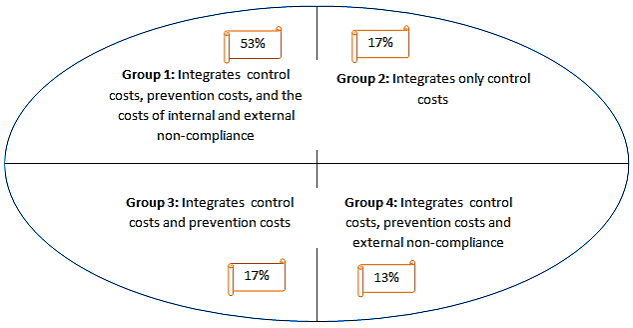


Fig. 3 Perceptions of Quality Control Integration: An Analysis of Respondent Perspectives and Groupings

By analyzing their responses, four distinct groups emerge, each offering a unique perspective on QC composition. The majority, represented by Group 1 comprising 53% of respondents, views QC as encompassing control costs, prevention costs, and the costs associated with both internal and external non-compliance. This comprehensive understanding suggests a holistic approach to quality management, where proactive measures to prevent defects and reactive measures to address non-compliance are integrated.

In contrast, Group 2, comprising 17% of respondents, perceives QC as including only control costs. This narrower focus indicates a limited perspective on quality management, emphasizing reactive measures without considering preventive actions. Similarly, Group 3 (also 17% of respondents) recognizes the integration of control costs and prevention costs but excludes the costs associated with non-compliance. This suggests an understanding of both proactive and reactive measures, albeit overlooking the consequences of non-compliance.

Group 4, representing 13% of respondents, aligns closely with Group 1 in understanding QC as integrating control costs, prevention costs, and costs related to external non-compliance. This perspective acknowledges both preventive measures and the consequences of non-compliance, with a specific focus on external factors.

Overall, the variations in respondents' perceptions highlight differing levels of understanding and emphasis on various elements within QC. While some respondents demonstrate a comprehensive grasp of quality management principles, others exhibit more limited or focused perspectives, potentially reflecting variations in knowledge or experience in quality management practices.

Quality cost management systems (QCMS) in the chemical and para-chemical industry

After gaining insights into manufacturers' perspectives on the cost of quality within the sector, our focus shifted towards understanding their awareness and attitudes regarding quality cost management systems (QCMS). We initiated this by inquiring whether they were familiar with QCMS.

Regrettably, more than half of the surveyed companies, comprising 51%, responded negatively to this query, indicating a lack of awareness or familiarity with QCMS. However, despite this initial unfamiliarity, a significant portion, constituting 78% of respondents, expressed keen interest in receiving training on quality cost management systems. In contrast, 22% of companies indicated a lack of interest in such training initiatives.

This highlights a potential opportunity for education and intervention within the sector, as there exists a substantial willingness among companies to engage with and enhance their understanding of QCMS through targeted training programs.

After gauging the manufacturing sector's understanding of quality cost, we proceeded to assess their familiarity with Quality Cost Management Systems (QCMS). We inquired whether they were acquainted with QCMS, and regrettably, 51% of the surveyed companies responded negatively. However, amidst this skepticism, a substantial 78% expressed keen interest in receiving training on quality cost management systems, highlighting an eagerness to bridge the gap in knowledge and implementation.

In contrast, among the 49% of companies already acquainted with QCMS, only 42% have implemented it, utilizing a variety of QC models. Predominantly, these implementations are grounded in the Process and PAF model, with notable adoption of the Harrington and Hermel model following closely behind. This discrepancy underscores the gap between familiarity and practical application, suggesting potential barriers or challenges in fully integrating QCMS into operational frameworks.

All companies with QCMS analyze their data but at different frequencies. The following Figure 4 illustrates the percentage distribution of analysis frequency among companies that utilize Quality Control Management Systems (QCMS) to analyze their data.

Figure 4 shows that the majority of these companies, accounting for 48%, conduct data analysis every month.

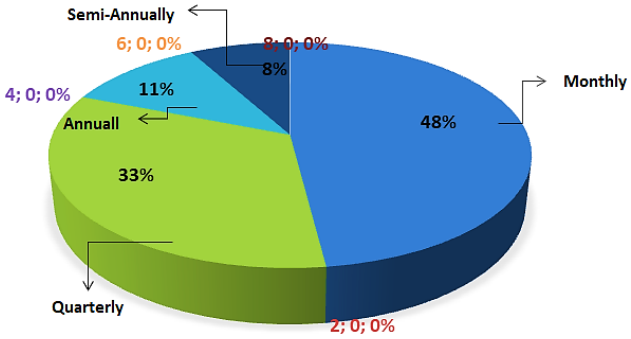


Fig. 4 Frequency of data Analysis among QCMS-Utilizing Companies

Following this, 33% perform analyses quarterly, 11% annually, and the remaining 8% semi-annually. These results indicate varying levels of engagement with data analysis among companies employing QCMS. The fact that nearly half of the companies opt for monthly analysis suggests a proactive approach towards monitoring and managing quality control processes. This frequency allows for regular insights into operational efficiency, potential issues, and opportunities for improvement. Quarterly analysis, undertaken by 33% of the companies, implies a slightly less intensive approach, likely reflecting a balance between resource allocation and the need for timely insights. The 11% of companies conducting annual analysis might prioritize other aspects of operations over frequent data analysis or have less dynamic processes that require less frequent monitoring. The lowest frequency, semi-annual analysis, chosen by 8% of companies, suggests a more reactive approach, where data analysis occurs less frequently, possibly due to resource constraints or less immediate quality control concerns.

Therefore, the variation in analysis frequency among companies using QCMS may underscore the flexibility and adaptability of such systems to accommodate diverse organizational needs and preferences. Companies may adjust their analysis frequency based on factors such as the nature of their operations, the complexity of quality control requirements, resource availability, and strategic objectives. While frequent analysis allows for timely detection and response to issues, it also demands greater resources and may generate more actionable insights. Conversely, less frequent analysis may suffice for some companies, particularly those with stable processes or limited resources, but it also carries the risk of overlooking critical issues or trends. Overall, the distribution of analysis frequency highlights the importance of aligning data analysis practices with organizational goals and constraints while ensuring effective quality control management.

Integrating the environmental aspect and well-being dimension in quality cost management systems is crucial for fostering sustainability and organizational development. By incorporating these elements, businesses align with ethical values, drive innovation, reduce risks, and enhance competitiveness, ultimately fostering a sustainable and prosperous future [53, 54]. This integration allows for the consideration of economic, environmental, and social criteria in the assessment of quality costs, leading to improved sustainability performance in product design and increased value of products [55]. It also enables the identification of opportunities to lower costs and increase profit through the evaluation of quality costs in the business value chain [56]. Furthermore, quality management practices facilitate firms in achieving environmental innovation and sustainability goals, while environmental innovation significantly enables organizations to achieve sustainability goals [22].

This strategic integration of environmental and well-being considerations is evident in our analysis of companies' perceptions towards these crucial aspects.

A substantial majority of these organizations, totalling 78%, have made concerted efforts to incorporate the environmental aspect into their business practices. Specifically, their focus lies on low-carbon waste management strategies. This statistic may speak volumes about the evolving consciousness among businesses regarding their environmental impact [31]. By integrating environmental considerations into their operations, these companies demonstrate a proactive stance towards sustainability. The emphasis on low-carbon waste management suggests a strategic approach aimed at reducing resource consumption, minimizing waste generation, and mitigating carbon emissions. Such initiatives likely stem from a combination of factors, including regulatory pressures, consumer expectations, and a genuine commitment to corporate social responsibility.

Equally noteworthy is the attention paid to the well-being aspect, with 69% of the analyzed organizations incorporating it into their operations. This facet encompasses a wide array of factors that directly influence the health, safety, and satisfaction of employees and stakeholders. Among the aspects considered are absenteeism, work-related accidents, staff demotivation, union impact, staff turnover, and burnout. This comprehensive approach to well-being may underscore the recognition among companies of the intrinsic link between employee welfare and organizational performance [28, 29]. High rates of absenteeism, work-related accidents, or staff turnover can signal underlying issues within the workplace environment,

such as poor working conditions, inadequate support systems, or insufficient employee engagement initiatives. By addressing these concerns, organizations aim to foster a healthier, more resilient workforce, ultimately contributing to enhanced productivity, morale, and overall business success [28, 29].

Challenges faced by companies in managing quality costs: Pareto analysis

As illustrated in Figure 5, we have utilized Pareto analysis as a tool to identify the primary obstacles encountered by the industry in implementing Quality Cost Management Systems (QCMS).

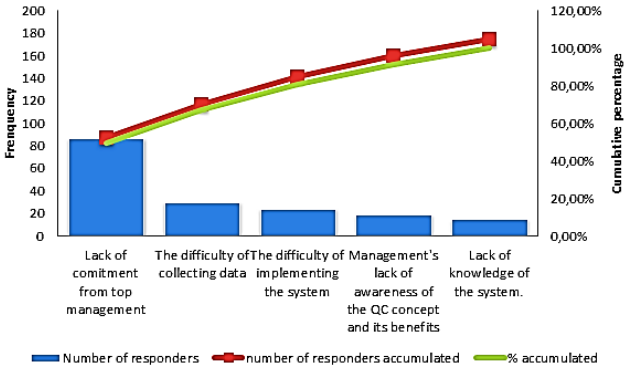


Fig. 5 Pareto diagram

The Pareto analysis conducted revealed several key obstacles hindering the successful implementation of Quality Cost Management Systems (QCMS) within the industry. Foremost among these challenges is the "Lack of commitment from top management," representing 49.71% of responses, making it the primary obstacle identified by respondents. This aligns with the Pareto principle, where approximately half of the issues stem from this single factor. Following closely is the obstacle of "The difficulty of collecting data," comprising 66.86% of accumulated responses. While significant, it ranks second in priority, trailing behind the primary obstacle. In third place is "The difficulty of implementing the system," representing 80.57% of accumulated responses. Although substantial, it is notably less prevalent than the top two obstacles. Additionally, "Management's lack of awareness of the QC concept and its benefits" accounts for 91.43% of accumulated responses, indicating its importance but less frequent occurrence compared to preceding obstacles. Finally, "Lack of knowledge of the system" encompasses all responses, highlighting it as the least frequent obstacle identified.

Applying the Pareto principle, it can be concluded that the majority of problems (approximately 80%) stem from just two factors: lack of commitment from management and difficulty in data collection.

These two factors are two major challenges faced by companies in managing quality costs. The implementation of the Cost of Quality (COQ) reporting system requires cooperation among departments, and the lack of it hinders the successful implementation of COQ [57]. Additionally, poor data quality leads to extra use of resources for finding the needed data, which can significantly impact the scope of quality cost management projects [58]. Concerning the data issues it could be as we found in term of quality and it could also be related to time Vianello et al. in their study related to Utilizing Cost-Benefit Analysis for Enhancing Industrial Safety in the Chemical and Petrochemical Sector they found that despite the availability of the needed tools, the primary challenge in the chemical and petrochemical sectors persists: the time-consuming nature of applying cost models, primarily due to the data collection process. Given the intricate nature of these facilities, extensive plant-specific information is required. Therefore, besides the necessity of a tool facilitating cost-benefit analyses, having a system to gather and handle plant-specific data for input would be beneficial. Recently, ANTEA has introduced a software solution called Inspection Manager, designed to aid in managing operational risks and facilitating decision-making processes [59].

These challenges are not limited to a specific region or industry. South African companies, for example, have identified preventive costs and appraisal costs as important categories of quality costs, but often ignore the opportunity cost [60]. Similarly, pharmaceutical companies in Eastern Europe face challenges in implementing Total Quality Management (TQM) due to a lack of senior management commitment and budgeting problems [61]. Quality cost management in the chemical industry presents Other chanlenges that were deteted by researches such as Identifying and ranking cost drivers that poses a potentiel challenge. Moreover, achieving optimal resource allocation to tackle quality concerns while balancing expenditure remains imperative for sustainable operations [62].

Overall, the commitment from management and the availability of accurate and reliable data are crucial for effective quality cost management.

Therefore, to enhance the situation, it would be prudent to prioritize efforts towards addressing these two primary obstacles initially. While other factors remain important, they may be considered less critical in the immediate term. This targeted approach can streamline efforts and maximize effectiveness in overcoming key challenges within the industry.

Comparison of quality costs across different subsectors within the chemical and parachemical industries

Comparison of quality costs across different subsectors within the chemical and para-chemical industries revealed noteworthy insights into variations and trends within the sector. The analysis unveiled disparities in quality cost allocation and management practices among distinct subsectors, shedding light on potential areas for improvement and optimization. Among the subsectors examined, including the manufacture of phosphoric acid and fertilizers/MDCP, artificial or synthetic fibers, soaps, cleaning products and perfumes, cement, ceramics, and briquets, differing patterns in quality cost distribution emerged. For instance, while some subsectors prioritized preventive measures to minimize quality-related expenses, others exhibited a more reactive approach,

focusing on addressing issues as they arise. Additionally, variations were observed in the proportion of quality costs allocated to different components, such as prevention, appraisal, internal failure, and external failure. Subsectors with stringent regulatory requirements or heightened consumer expectations tended to allocate a larger share of resources to preventive measures, aiming to proactively mitigate quality risks and ensure compliance. Conversely, subsectors characterized by high product complexity or volatility in market demand often allocate significant resources to appraisal and internal failure costs, reflecting the challenges associated with maintaining quality standards in dynamic environments.

Furthermore, the comparative analysis highlighted the impact of organizational size and maturity level on quality cost management practices. Larger firms with higher maturity levels tended to allocate more resources to preventive measures and invest in advanced quality management systems, leveraging economies of scale and organizational capabilities to drive efficiency and effectiveness in quality control. Therefore, the comparison of quality costs across different subsectors underscores the multifaceted nature of quality management within the chemical and para-chemical industries. By identifying sector-specific challenges and opportunities, organizations can tailor their quality management strategies to enhance competitiveness, operational efficiency, and customer satisfaction.

Strategies for reducing quality costs and improving overall quality management

The strategies aimed at reducing quality costs and enhancing overall quality management within the chemical and para-chemical industry generally encompass proactive measures, resource optimization, effective utilization of Quality Cost Management Systems (QCMS), and the integration of comprehensive quality management frameworks.

Proactive measures emerge as critical strategies for cost reduction, emphasizing preventive actions to mitigate defects and errors. Investments in preventive maintenance, process improvements, and employee training programs are highlighted, aiming to minimize the occurrence of quality issues and associated costs [63]. Additionally, fostering a culture of quality supported by strong leadership and employee engagement is emphasized as instrumental in driving continuous improvement initiatives.

Resource optimization strategies focus on streamlining production workflows, implementing lean manufacturing principles, and leveraging advanced technologies such as automation and data analytics. These measures not only enhance efficiency but also reduce waste and improve product quality [64]. Strategic supplier partnerships and supply chain optimization initiatives are also underscored as contributing factors to cost reduction by ensuring consistent availability of high-quality raw materials and components [64].

Effective utilization of Quality Cost Management Systems (QCMS) emerges as a pivotal strategy, enabling companies to identify cost-saving opportunities and allocate resources efficiently. By enhancing data collection and analysis capabilities, companies can gain actionable insights into quality-related expenditures and prioritize investments for maximum impact [13]. Moreover, fostering cross-functional collaboration facilitates root cause analysis of quality issues and targeted solutions implementation.

Integration of these strategies into comprehensive quality management frameworks empowers companies to achieve sustainable cost reductions while enhancing product quality, customer satisfaction, and competitiveness [13]. However, effective quality cost management necessitates ongoing commitment from top management, continuous monitoring and evaluation of performance metrics, and adaptation to evolving market dynamics and regulatory requirements [65].

The strategies highlighted in the literature sources complement each other, emphasizing the importance of prevention costs, continuous value management, and the adoption of innovative decision support systems [65]. These strategies align with industry-specific needs, facilitating targeted cost reduction and enhanced company performance. Additionally, routine management practices, performance evaluation, and quality measurement implementations are emphasized for their role in reducing maintenance expenses and improving operational efficiency [65].

Augmenting total quality management (TQM) through the consistent implementation of standard operating procedures (SOP) and integration of Lean and Six Sigma methodologies are underscored as indispensable strategies [64]. Furthermore, fortifying the effectiveness of Quality Management System (QMS) certification and adopting Statistical Process Control (SPC) and Engineering Process Control (EPC) are highlighted for their potential to enhance product quality and curbing costs effectively [66].

Overall, the recommended strategies underscore the importance of a multifaceted approach to quality cost management, integrating proactive measures, resource optimization, effective utilization of QCMS, and comprehensive quality management frameworks. By embracing these strategies, companies can navigate the complexities of quality management within the chemical and para-chemical industry, achieve sustainable cost reductions, and enhance competitiveness in the global marketplace.

CONCLUSION

In conclusion, the findings from this study shed light on the current state of quality management practices within the Moroccan chemical and para-chemical industry, particularly focusing on the awareness, implementation, and obstacles surrounding Quality Cost Management Systems (QCMS).

There exists a significant adoption of Quality Management Systems (QMS) among companies, with a substantial portion holding ISO certifications, indicating a commitment to international quality standards. Proactive approaches to quality control are prevalent, yet challenges

such as underestimation of quality costs persist. However, the study identifies key strategies for reducing quality costs and improving overall quality management, emphasizing preventive measures, process optimization, and effective utilization of QCMS. Addressing obstacles such as lack of commitment from top management and data collection difficulties remains essential for successful quality cost management.

Further supplementing these findings reveals that QCMS adoption remains relatively low within the Moroccan market, especially in the sector under examination. While a majority of companies have implemented QMS, there is a notable gap in certifications related to environmental and occupational health and safety management systems. Moreover, various perceptions and integration practices regarding Quality Cost (QC) among companies highlight diverse understandings and approaches.

Despite the benefits QCMS offer in enhancing efficiency and productivity, companies face challenges such as a lack of commitment from top management, data collection difficulties, and limited awareness of QC. However, integrating environmental and well-being aspects into QCMS emerges as a promising avenue for enhancing organizational sustainability and employee welfare. Also the validity and reliability of survey measures used to assess quality cost management practices may be a limitation. Ensuring that survey items accurately capture the constructs of interest and demonstrate consistency over time is essential for drawing meaningful conclusions.

Overall, the study underscores the pressing need for companies to proactively manage quality costs and invest in QCMS adoption. By embracing comprehensive quality management frameworks and addressing key obstacles, companies can achieve sustainable cost reductions, enhance product quality, and improve competitiveness in the global market landscape. To continue the efforts towards strong quality management data and conclusions in this sectors we will study a statistical relationships within the dataset to to deepen the study and analysis of the results and data obtained.

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