# Visualization of the Process of Tracking Quality Using Quality Costs: An Empirical Study

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***Abstract*** **– The primary objective of this paper is to find out whether we can use the quality cost model as a tool for visualizing the quality targets in the quality management using the quality costs. The analysis showed that a graphic interpretation of the quality costs model in the companies makes the quality targets "more visible" and "more representative". The visualization of the quality costs model focuses the efforts of management to use the graphic interpretation of the quality costs for the purposes of visibility, monitoring, comparison with the quality targets at the company level, and beyond during negotiations.**

***Keywords*** **– quality costs, PAF model, prevention costs, appraisal costs, failure costs.**

## 1. Introduction

The core reason for the existence and the application of cost quality models relates to the need to improve quality, particularly from the point of view of efficiency and effectiveness [1], so that companies can compete on the market in the long run and meet the demands of the consumers.

The management of quality costs by generating quality costs models with a view of improving quality, reducing the actual costs of quality, and increasing productivity is particularly important for the strategic cost management also known as managerial accounting [2]. Therefore, it is no accident that quality costs are a management tool. Moreover, the quality costs speak with the language of managers, i.e., the language of money that product or service was not done right from the first time [3].

According to [4], comprehensive understanding of quality costs is the key to effective quality management, at both the corporate and operational level. In practical sense, the most prevalent approach for reconciling two conflicting objectives: the minimization of the quality cost and the maximization of the quality of conformance is based on the monitoring of the cost of quality as a tool to systematically improve quality and pursue excellence by consistently reducing failure in a timely fashion [5]. Hence, quality costing is one of the most important techniques implemented in the field of quality engineering and management [6].

The literature presents: a descriptive interpretation of the quality costs models, which describes the categories in the models [7]; a graphical interpretation which illustrates the relationship between the quality costs categories, as well as the relationship between the quality costs categories and the total quality costs and the quality level [4]; and a mathematical interpretation, representing mathematical expressions for calculating of the quality costs elements, categories, and total quality costs [8].

The quality costs measurement system is required to be able not only to identify all quality costs elements and then to show the true value of the quality costs (by categories and by quality costs

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elements), but also to determine the places where they track the quality costs to their primary sources and measure the occurrence of the quality costs in real time [9].

However, one thing that causes turmoil in the scientific and practical community refers to the need to investigate whether the concept of quality is a continuously current concept and whether it relates to new research trends.

The analysis of the quality management research trends involving scientific papers published in eight academic journals between 2000 and 2019, confirmed the costs of quality in 17 long-term trends out of a total of 45 trends, with a decline in popularity in the last years, mostly related to the computerization of process management. Something that sparks attention are the emerging trends that warrant future research such as corporate social responsibility, innovation and creativity, sustainability, as well as future research from the perspective of an integrated view of the measures of knowledge management, quality costs and process capability [10].

The study of Dimitrantzou et al. [11], used the affinity diagram and pareto diagram to analyze future research topics related to quality costs, published in well-known academic databases (Emerald, Elsevier, SpringerLink, Taylor & Francis, Wiley, and Scopus) during the period from 2010 to 2018. It showed that the vital themes of future research suggestions are sectors, subsectors and units, impact on quality cost elements, quality cost data and information, methods and analysis, and countries, which represent 80% of the research suggestions. The upward trend of the quality costs publications is significant in Europe and Asia, focusing on the manufacturing sector. The study showed a lack of purely theoretical papers and a prevalence of empirical studies. In order to fill this gap, the study recommends that theoretical research should encompass the interdisciplinary nature of quality costs in different contexts and disciplines, such as management, engineering, accounting, computer science, logistics, and mathematics.

According to the above mentioned, this paper would like to contribute to the evolving discussion of discovering new potentials (strengths) of quality costs, and to expanding their application as a useful management tool. This primarily arises as a logical consequence and a continuation of the evident positive experiences with the application of quality costs confirmed by many experimental studies so far [12], [13], and [14].

The study should help answer the following research questions: Can a graphical interpretation of the quality costs models be useful as a tool that will provide visibility of the quality targets monitoring process within quality management using quality costs? Secondly, what are the benefits of this innovative application of the quality costs model with respect to painting a picture of quality?

The rationale behind these research questions resides in the pressure facing managers in the process of planning, execution, evaluation, and improvement of company operations, i.e., when, in order to make proper and timely decisions, management needs a holistic approach to considering financial and nonfinancial data related to the quality targets presented in a visual, easy-to-understand, and systematized way.

Thus, we define the following research objectives. First: acquire broad knowledge regarding the use of quality costs potential. Second: graphically interpret the quality costs model and present it as an innovative graphic tool to express quality, i.e., a tool that will help visualize the quality targets.

In the interest of proving these objectives, in order to provide overview of different streams of thinking, this paper is organized as follows: (1) Introduction; (2) Literature review; (3) Research Methodology; (4) Empirical research; (5) Conclusion; (6) References.

## 2. Literature Review

Understanding of quality according to Freiesleben [15], often is accompanied with two interrelation aspects: quality of conformance to design and quality of design, or with the two complementary dimensions: production quality (efficiency of production), a technology-driven dimension and design quality (product and production design) as a market-driven dimension.

In the quality cost literature, Garvin's dimension of quality - conformance quality is used to measure the quality level [16], and is often measured by percent defective at the manufacturing plant and error rate at inspection [8], or as a function of all the quality improvement efforts (effective quality capital) [17], while in the study of Ayati & Schiffauerova [18], is presented as multiplication of actual good component parameter and lead-time deviation variable.

The failure costs, colloquially called "hidden factory" and the costs of the activities to improve quality which include prevention costs and appraisal costs, also known as the cost of improving quality represent the quality costs concept, i.e., the broadly accepted PAF (Prevention, Appraisal, Failure) model. The basic assumption is that investing in activities of prevention and appraisal will decline the cost of failure (internal and external) and further investing in prevention will decline appraisal costs [4].

Both the internal and the external failures occur as a consequence of poor-quality product design, materials, or processes [19].

The failure costs (internal and external) and the appraisal costs, i.e., costs that do not add value [20], amount to up to 95% of the total quality costs [21]. Since it dominates the overall cost of quality, the elimination of such costs becomes a priority in the agenda for a competitive advantage and sustainability within company operations.

Duarte et al. [5] suggest that the most of the firm's savings in failure cost appears with optimal quality improvement program, that means elimination of failures must be as fast as possible after occurring. On this way and monitoring of quality costs either quarterly, weekly, or daily, can focus the investments in preventive or appraisal activities.

According to Velkoska & Tomov [22] quality costs should not be underestimated, that is corroborated by the fact that they contribute significantly to the total product creation costs that can reach up to 40%, or 38% of the company sales value or 33% of the value of the sales contracts. The same study presented an overview of published research studies about the extent to which companies apply quality costs, which quality costs categories do usually measure, as well as the quality costs measured values.

Many researchers have published studies correlating the quality costs categories, correlating the categories with the total quality costs, as well as with the level of quality [23], [24], and [25]. It is worth noting that the quality costs categories contain specific elements of the quality costs dependent on the nature of the company, its size, the type of products it produces, the organizational and technological conditions, and other considerations.

Because no unified method exists to determine them, which according to Yang [26], represents one of the most important prerequisites for an effective and efficient system for managing quality costs, according to Purguslove & Dale [1], this can lead to many debates and confusion. This particularly impacts the relevancy of the results from the comparative analysis of the quality costs of the companies.

The verification of scientific thought regarding quality costs is a feature of the modern age. Many studies present an overview of successful practices of companies which have implemented a quality cost measuring system. A reduction of the failure costs at a low or no subsequent increase in the conformance costs was registered in the study of Ittner [27].

The study of Kaur [28] confirmed that the quality costs as a percentage of the sales revenue do not significantly differ between private and public companies. The majority of the companies use the cost of quality for strategic cost management as well.

The experimental study of Mahmood et al. [29], showed that the consistent downward trend of the quality costs during a period of two months initiated a reduction of the quality costs by 25%, improvement of productivity by 17%, and an increase of profitability of the company by 11%.

The study of Chopra & Garg [25], showed a reduction of the costs of nonconformance correlated to the growth of the costs for prevention and the costs for appraisal, i.e., a reduction of the total costs of quality from 20.9% to 14.24% in three years. The study of Psomas et al. [30], confirmed that appraisal activities have a very significant effect on the reduction of the internal and external failure costs in comparison to the preventive activities.

A reduction of the total costs of quality from 16% to 12% of the revenues is registered in the study of Ramdeen et al. [13].

According to Sower et al. [31], American companies with a higher level of the quality system maturity reported smaller quality costs. It means that the quality cost distribution does change after implementation of a quality system.

Irrespective of whether dealing with a strategy become a market leader through cost leadership or generating product diversity, or application of a focused strategy [15], the application of quality costs as a performance measure for operational processes and measure (tool) of overall organizational performance enables quality costs optimization and profit increase as a result of good company managerial accounting, according to Staiculescu [2].

The research in study of Lim et al. [19], looks at the quality costs optimization through the prism of an optimal combination of prevention costs and inspection costs in order to minimize the total quality costs. The total quality costs are lower for higher levels of quality as they do not require more spending on prevention and appraisal activities, according to Plewa et al. [32].

The study of Farooq et al. [33], assesses the application of the quality costs model as significant with respect to the optimization of the quality inspection conducted by identifying the conformance rates and external failure premium, while the study of Hamrol et al. [34], looks at the value-added criterion.

The novelties related to environmental protection and the inclusion of environment costs in the total quality costs enables greater visibility of the degradation of the natural resources, which in turn helps the decision makers – the managers make more efficient decisions about investments and the return on investments with respect to environmental protection. From a national policy making viewpoint, government authorities may conduct economic assessments as a prerequisite for enacting environmental legislation, in order to reduce environmental-related global failure cost and to stipulate a minimal level of product's environmental quality [35].

In the study of Ayach et al. [36], it was registered that environmental non-quality (pollution, noise), social non-quality (work accident, demotivation, etc.)

and supplier non-quality are the less integrated elements to the computing of cost of quality, while the study of Obied-Allah [37] discusses new category – recycle cost into a quality cost model in supply chains.

According to Kambanou & Lindahl [38], there is a lack of research related to end-of-life stage of the product and therefore less emphasis is placed on disposal costs.

## 3. Research Methodology

This study applied an integrated methods approach to conduct the research in a scientific and transparent manner, allowing its replicability.

First, we provide a shorth theoretic synopsis of the benefits of the application of quality costs. The use of reviewed publications with prevalent conceptual and methodological rigor ensures the high quality of this study.

Second, the empirical research part consists of the practical application of quality costs model in response of research questions for monitoring the management objectives (quality targets) as aid in the hands of decision makers in their management activities as well contributions from quality cost application. The empirical research will be implemented in three stages. The first stage led to the formation of a preliminary expert team tasked to prepare the survey questionnaire as a research method. The second stage involves defining the expert group which will participate in the research, conducting the survey and collecting the responses. This stage also employed the panel discussion technique.

The third stage involves the processing of the responses and presenting the results.

### *3.1. Subject of the Empirical Research*

The empirical research looks at a selected target group of automotive industry companies, i.e., affiliates of international companies that produce automobile parts on the territory of the Republic of North Macedonia, conducted in the period from 2016 to 2020.

The authors invited 9 companies to participate in the research of which only 4 companies fulfilled the criteria for participation, were ready to fully respond to our requirement, and showed a strong interest to cooperate and share quality costs data. In addition, the research guarantees the anonymity of the expert and the companies, as well as of the responses provided by the companies which will be used solely for scientific and research purposes.

The empirical study researches a generic quality costs model in the management of the quality targets in the selected companies. This gave rise to the survey questionnaire, structured in two parts.

The questions in the first part of the questionnaire aim at painting a picture of the company demographics and the status of the application of standards and management systems which, in turn, will provide objective evidence of the proficiency of the companies and their experts in the area of quality.

The second part of the questionnaire asked the companies to describe, in detail, their management objectives (the quality targets), the level of tracking, and how they monitor and maintain quality management.

After the researchers assessed the conditions under which the selected companies managed the quality targets, they decided to ask two companies (A, B) for data about the elements and the categories of the generic model at a specific project level and during one calendar year, to ask one company (C) to provide data for all of their projects for a selected calendar year and to ask one company (D) for annual data for all current projects for a period of four years (2017-2020).

The presentation of these four cases helps comprehensively answer the research question regarding the usefulness of the graphical presentation of the quality costs model for the visibility, the monitoring, and the evaluation of the implementation of the quality targets.

The research excludes data from 2020 because, due to the Corona Crisis, the authors did not expect that the quality costs data for 2020 would be relevant in the data series for the entire period. Due to the sensitivity of the research subject, the companies provided the required quality costs data as a percentage of their sales value.

The questions in the third part of the questionnaire relate to value of the categories and the elements of the provided structure of the generic quality costs model which involves four categories, i.e., prevention costs, appraisal costs, internal failure costs, and external failure costs. The generic model structure derives from the theoretical research of the literature sources in this study, conducted by the authors of this paper.

### *3.2. Data Collection, Editing, and Analysis*

During the collection of the data, each company was asked to assign a responsible officer (expert) for responding to the questionnaire. The responses to the questions from the first part of the questionnaire were systematized and analyzed using a descriptive and statistical analysis, while the questions from the second part of the questionnaire are systematized in a descriptive – narrative form.

The responses to the questions from the third part of the questionnaire were systematized in Excel and were presented graphically by plotting the quality costs categories curve and the total quality costs curve using a second order interpolation.

It is worth noting that, when drawing the quality costs curves, the values of the costs are closest to the real time of the costs due to the very short time periods of production, delivery, and use of the products, as well as the high level of maturity of the quality system.

## 4. Empirical Research

### *4.1. Results of the Data Analysis from the First Part of the Questionnaire*

The results from the analysis of the responses to the first part of the questionnaire showed that the companies, within their organizational structures, have a Quality Sector with a Quality Control Department and a Department for Introduction and Maintenance of the Systems for Management of Quality, Health and Safety, Environment, etc. The analysis showed that the companies are committed to applying and improving certified quality management, environmental, health and safety at work systems, as well as to the application of the standards IATF 16949:2016 and VDA6.3:2016. All companies understand the quality costs and apply systems to identify, track, quantify, and report such costs, especially in the product design and development phase, as corroborated by the panel discussions with the company experts, i.e., control manager, quality manager, production manager, and financial manager.

### *4.2. Interpretation of the Results of the Data Analysis for the Second and the Third Part of the Questionnaire*

After plotting the quality costs model, the visualization of the models was compared to the narrative and descriptive interpretation of the quality targets made by the experts, and the following results were obtained.

Figure 1. shows the graphical interpretation of the quality costs model for company A that tracks quality costs from the very start of the project implementation. The company has established the following quality targets: acceptable internal failure costs at most 3.3% of the project sales, as well as a predefined number of complaints. Only the company knows the complaints data and the research accepted them as a trade secret of the company. As a generator for triggering quality improvement activities, the company considered in the increased number of external failures as evidenced by the complaints from the customers.

Company A is an example of an increased number of complaints due to an identified nonconformity and unmet product functionality requirements after delivery to the customers. The increased number of complaints triggered actions to analyze the complaints and nonconformities, detect the reasons for the nonconformities in the design and prevention of future nonconformities, repairing the returned products, and recording of scrap which caused the external failure costs to increase to 7.5% of sales (first quarter), which represented a serious threat to the project's profitability.

The company invested in prevention and appraisal activities (conformity costs), which helped improve the quality of the product and reduce the external failure costs, as well as the internal failure costs during the third and the fourth quarters. At the end of the fourth quarter, the company registered a relaxation of the prevention costs which remained at the level required to maintain the level of quality, through preventive education, maintenance of the quality management system, and preventive maintenance of the equipment.

There was a positive correlation between the conformity costs and external failures costs, the conformity costs, and the internal failure costs, as well as between the conformity costs (prevention and appraisal costs) and the nonconformity costs (costs of internal failures and costs of external failures). This confirmed that the prevention and appraisal activities yielded results, i.e., were effective. This leads to the conclusions of the research study [25], [31] and [39].

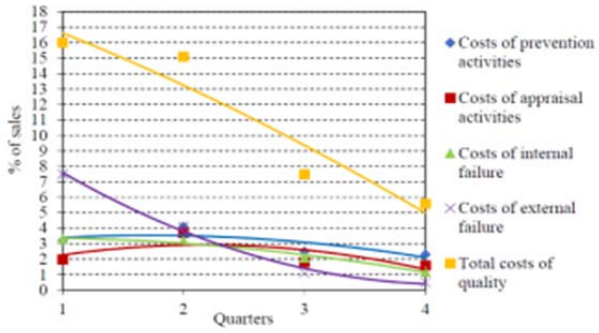


*Figure 1. Graph of the cost quality model (Company A)*

The company expert thought that the increased number of complaints is probably due to production quality nonconformities, because investments in prevention and appraisal activities have led to a reduction of the internal failure costs, which would be characteristic for design nonconformities, because in such a case, the internal failure costs would not necessarily decrease.

Figure 2. shows a graphic interpretation of the quality costs for company B who also tracks the quality costs since the start of project implementation. However, here the analysis of the

high number of internal failure triggers activities to improve quality. The company tracks the defined quality target that internal failure costs do not exceed 6.2% of the project sales.

Company B recorded a higher number of internal failures in the first quarter which signaled insufficient quality maintenance activities and the need to invest in activities to analyze the nonconformities, detect the causes and the source of the failures, remedy the nonconformities, and register scrap, which led to an increase in the internal failure costs. The company continues to invest in prevention activities to improve quality (activities for researching, planning, and designing of quality), in order to eliminate the reasons for any nonconformities in the second quarter. The improvement of quality was also accompanied by investments in appraisal activities in the second quarter, which in turn improved the level of quality of the quality conformance assessment.

These investments contributed to improving the quality of the product and reduce the costs of internal failures (second quarter), which suggests a positive correlation between the conformance costs and internal failure costs. A positive correlation was also registered between the conformance costs and the external failure costs. The trend of drastic relaxation of the internal failure and external failure costs continued in the third and in the fourth quarter. This conformed the effectiveness of the activities for prevention and appraisal. This case shows the reduction of the internal failure costs and suggests a reduction of the external failures costs, which means that this leads to the attainment of a higher level of conformity of the production quality, which can relate to the results of the studies [25], [31] and [39].

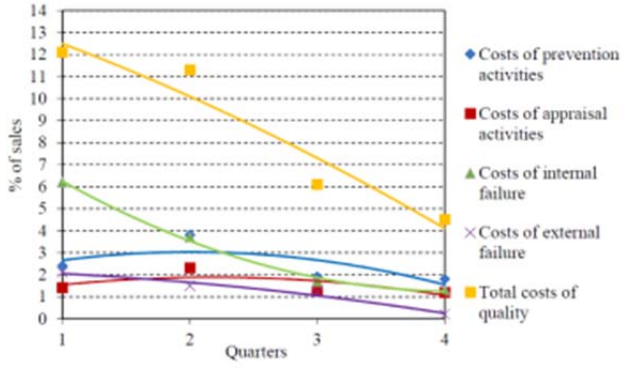


*Figure 2. Graph of the cost quality model (Company B)*

Figure 3. shows a graphical interpretation of the quality costs for company C. This company expresses the quality costs value as a percentage of the total project sales, plans the quality costs in advance, accepts them as quality targets, and they trigger activities for management of the level of quality in the company, as well as other appropriate activities.

The planned value of the total quality costs amounts to at most 7.3%, the value of the prevention activities costs – 1.7%, the value of the appraisal activities costs – 2.5%, the value of the internal failure costs– 2.7%, and the value of the external failure costs – 0.4%.

According to the company expert, the total quality costs, and the costs for external failures in all quarters did not exceed the planned values, but the preventive activities posed a problem.

Not only did the investments in prevention activities in the first quarter (higher than the planned 1.7%), reduce the internal failures, but rather they increased them (to 3.5%, which exceeded the planned value of 2.7%). In spite of the relaxation of the prevention activities (from 2.5% in the first quarter to 2% in the fourth quarter, which exceeds the planned value of 1.7%), the value of the internal failure costs increased (from 3.5% in the first quarter to 4.4% in the fourth quarter).

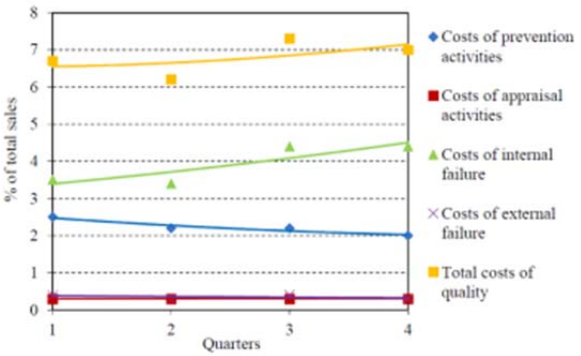


*Figure 3. Graph of the cost quality model (Company C)*

This showed that sometimes investments in prevention do not yield the expected results, which, according to the expert, leads us to the conclusion that actual opportunities to improve the quality were not identified, i.e., the preventive activities were not effective (for comparison, see the study [30]).

The fact that the external failure costs ranged within the planned values, suggests that the company has a problem with the internal quality, particularly with respect to the production quality, while the design quality is within the plan.

Figure 4. shows a graphical interpretation of the long-term quality costs in company D, during a period when the company implements multiple projects at the same time and introduces new project on an ongoing basis and where the company proactively implements prevention activities with a view of minimizing the internal and external failure costs. The value of the internal failure costs for all projects of at most 1%, and the value of the external failure costs of at most 0.3% of the total company sales represented established quality targets.

The company expert confirmed that the company aims to incorporate quality from the very beginning of product creation in order to achieve the lowest possible internal failure costs, and especially the lowest possible external failures costs and, at the same time, to relax the appraisal activities costs. The company paid particular attention to the activities for input control of the products from the suppliers, which, as a cost, represented a high percentage of the appraisal activities costs.

A positive correlation was registered between the conformance costs and the nonconformance costs in the context of a mature company with respect to the quality of its overall operations, which reflects a company dedicated to maintaining a very high level of quality, which on the other hand opens a discussion about the feasibility of intensive continuous investments which is not in line with the studies of Plewa et al. [32] and Ittner [27].

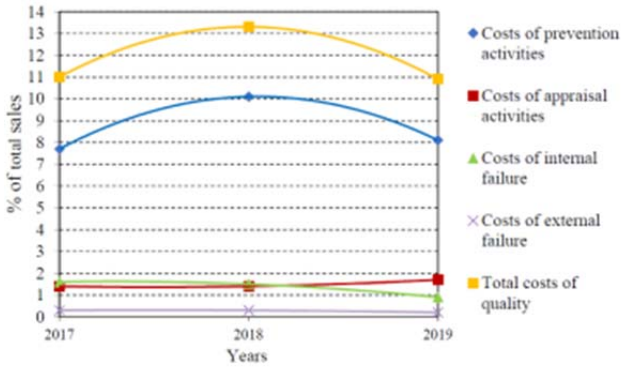


*Figure 4. Graph of the cost quality model (Company D)*

The analysis of the results obtained for all four companies suggests that we have sufficient reasonable arguments to confirm that the graphical interpretation of the quality costs model makes the quality targets more representative by visualizing the very process of monitoring and maintaining them.

## 5. Conclusion

### *5.1. Theoretical and Managerial Contributions*

The results of the empirical research in this paper contribute to the enrichment of the understanding of the importance, significance, and usefulness of the quality costs model application in quality management, since they directly reflect the practice and the experience of the companies.

This experimental study confirmed the primary goal of this paper to expand the knowledge about the application of quality costs with a view of encouraging managers to commit to a substantive implementation of quality costs, i.e., to identify properly and continuously, coherently, consistently, and systematically, monitor, analyze, disseminate, and utilize the interdependencies of quality costs with a view of monitoring and sustaining the quality targets.

The theoretical contribution features an innovative application of the quality costs model involving a graphical picture of quality. In other words, the graphical interpretation of the quality costs model expressed by the dynamism of the quality costs model categories can serve as tool that will make the company quality targets more visible and more representative. This provides the management of a company with a visual image of the process of monitoring and achieving the quality targets, i.e., allows management to continuously follow the changes, the behavioral trends of the quality costs categories, which in turn effectuates timely and proper decision making in the management activities of planning, control, and improvement of quality. More specifically, it can cumulatively fulfill the processes of problem solving, decision making, problem-prevention mentality, risk-thinking, rethinking processes, meeting customer specific requirements, and customer-oriented product design with a view of achieving the quality targets at the product, project, and company level.

Something that makes the graphical interpretation an especially user-friendly tool for managers in the possibility of an integrated visualization of the quality cost categories, the participation in the investments on one hand, as well as the failures and the losses on the other hand. Since the value of the quality costs can be expressed as a percentage of a specific financial parameter, such as sales, this retains the discretionary right to non-transparency of the financial assets of the quality costs, which, at the same time, contributes to greater accuracy, objectivity, and relevance in representing the quality costs. In addition, the decision makers can feel more comfortable in exchanging their views, discussions, conclusions, and proposals in the complex relationships within and between the companies.

This opens up the horizon for comparing graphical interpretations of quality costs models at the level of different projects or different products with the same or with different quality targets, so that, by knowing the behavior of the quality costs categories, the decision makers can determine reasons for the lesser or greater profitability of projects, products, or buyers, which any company ultimately aims to achieve. This especially stands out when companies cooperate with each other, particularly during the selection and evaluation of company suppliers of intermediate goods and raw material, as well as in the process of making decisions about joint partnerships, investments, and operating on the global market.

Considering that modern business processes also commit to socially responsible aspects when looking

at costs such as best practices and legislative solutions for protection of people, health, and the environment, proper waste management, utilization of renewable energy sources, implementation of energy efficiency solutions, high level of awareness about socially responsible solutions, consumer protection, humane solutions, national regulation and quality, international conventions, etc., the pressure on the companies will intensify in the near future. Therefore, it is a matter of time when companies will commit to identifying and measuring of new relevant elements of the quality cost model categories. Thus, with a modern understanding of the structure of the quality costs model, the graphical interpretation of the model gets additional merits not only for the purposes of management, but for society as well, because it will visually reflect the resource degradation in the companies.

Hence the national quality regulation, the chambers of commerce, the professional organizations, the professional and the scientific public in the field of quality, the national bodies and institutions will become consumers of quality costs data.

This naturally imposes the need for availability and inclusion of the quality costs as input referent values for comparative analyses at the level of products, companies, or industries with a view of creating policy for national economies and, in the near future, global sustainability policies.

In the broadest sense, the quality costs will be increasingly needed for the integration of company values, national socioeconomic values, and the global values with a view of achieving sustainable overall operations of the nations.

All of this answers the research question about the benefits of such an innovative application of the quality costs model in painting a picture of quality. Above mentioned highlights the importance of application quality cost models and confirms the relevance of the work towards the improvement of theory and managerial practice.

### *5.2. Limitations and Future Scope of Study*

The empirical research has several limitations. The first limitation of this empirical study is the perhaps small number of companies (four) from the automotive industry. Still, we considered the sample to be representative since this is the most advanced industry and North Macedonia is a small country. In the future such research should be conducted in more companies in this industry from the Balkans, and other research should be conducted that will enable comparisons with companies from other industries. The second limitation involves the sensitivity of this subject matter, since this involves collection of financial information from companies in a developing country, which can be subject to a certain level of bias when submitting quality costs values. Generally, managers are still reluctant to transparently express their successes and failures in the company. On one hand, the confirmation of a company's success can lead to a justified demand from customers to reduce the price of its products since they perceive that the company operates efficiently and generates extra profit. On the other hand, if a company is less successful, then this can make the company afraid that their reputation and rating, as well as the consumer trust might be jeopardized and even lost and that the sales will decline. Therefore, it was exceptionally difficult and, in some of the nine originally invited companies, it was completely impossible for the research team to talk about quality costs data.

Future research should focus on the graphical representation of the modern elements in the structure of the quality costs categories and their impact on the other categories and their elements. With that in mind, we propose the following research questions:

1) How do elements from the prevention and appraisal categories influence the behavior of the internal failure costs, and what effects do they have relative to achieving production quality and design quality?
2) What does the gradient of influence of the elements from the internal failure costs category show relative to the reduction of the external failure costs, viewed in the context of production quality and design quality?

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**References**

[1]. Pursglove, A. B., & Dale, B. G. (1995). Developing a quality costing system: key features and outcomes. *Omega*, *23*(5), 567-575.

[2]. Staiculescu, O. (2012). A new vision of quality cost: an essential optimization tool for managerial accounting. *Procedia-Social and Behavioral Sciences*, *62*, 1276-1280.

[3]. Abdelsalam, H. M., & Gad, M. M. (2009). Cost of quality in Dubai: An analytical case study of residential construction projects. *International journal of project management*, *27*(5), 501-511.

[4]. Vaxevanidis, N. M., & Petropoulos, G. (2008). A literature survey of cost of quality models. *Journal of engineering*, *6*(3), 274-283.

[5]. Duarte, B. P., Oliveira, N. M., & Santos, L. O. (2016). Dynamics of quality improvement programs–optimal investment policies. *Computers & Industrial Engineering*, *91*, 215-228.

[6]. Mantri, S., & Jaju, S. (2016). Cost of quality management in Indian industries: A practical insight. *International Journal for Quality Research*, *11*(3), 491-506.

[7]. Hedesiu, D. M., Popescu, S. G., & Dragomir, M. (2012). Critical Analysis on Quality Costs Models. *Calitatea*, *13*(131), 71.

[8]. Castillo-Villar, K. K., Smith, N. R., & Simonton, J. L. (2012). A model for supply chain design considering the cost of quality. *Applied Mathematical Modelling*, *36*(12), 5920-5935.

[9]. Velkoska, C., Tomov, M., & Kuzinovski, M. (2018). Theoretical Aspects Related to the Creation of Algorithm for Quality Costs Measurement System. *Journal of Production Engineering, 21*(2), 65-68.

[10]. Wawak, S., Rogala, P., & Dahlgaard-Park, S. M. (2020). Research trends in quality management in years 2000-2019. *International Journal of Quality and Service Sciences*, *12*(4), 417-433.

[11]. Dimitrantzou, C., Psomas, E., & Vouzas, F. (2020). Future research avenues of cost of quality: a systematic literature review. *The TQM Journal*, *32*(6), 1599-1622.

[12]. Banasik, M. A., & Beruvides, M. G. (2012). A case study of the costs of quality: Water utilities. *Engineering Management Journal*, *24*(2), 3-14.

[13]. Ramdeen, C., Santos, J., & Chatfield, H. K. (2007). Measuring the cost of quality in a hotel restaurant operation. *Management*, *19*(4), 286-295.

[14]. Modhiya, S., & Desai, D. (2016). A review on cost of quality methodology and hidden costs in manufacturing industries. *REST Journal on Emerging trends in Modelling and Manufacturing*, *2*(4), 87-94.

[15]. Freiesleben, J. (2010). Proposing a new approach to discussing economic effects of design quality. *International journal of production economics*, *124*(2), 348-359.

[16]. Orm, M. B., & Jeunet, J. (2018). Time cost quality trade-off problems: a survey exploring the assessment of quality. *Computers & Industrial Engineering*, *118*, 319-328.

[17]. Rosiawan, M., Laksono Singgih, M., & Widodo, E. (2019). Model of quality costs and economic benefits of a business process of manufacturing companies. *Cogent Engineering*, *6*(1), 1678228.

[18]. Ayati, E., & Schiffauerova, A. (2014, November). Study of cost of quality behavior in manufacturing supply chain based on the quality maturity status. In *ASME International Mechanical Engineering Congress and Exposition* (Vol. 46637, p. V014T08A006). American Society of Mechanical Engineers.

[19]. Lim, C., Sherali, H. D., & Glickman, T. S. (2015). Cost-of-quality optimization via zero-one polynomial programming. *IIE Transactions*, *47*(3), 258-273.

[20]. Daunoriene, A., & Katiliute, E. (2016). The quality costs assessment in the aspect of value added chain. *Quality Innovation Prosperity*, *20*(2), 119-144.

[21]. Williams, A. R. T., Van der Wiele, A., & Dale, B. G. (1999). Quality costing: a management review. *International Journal of Management Reviews*, *1*(4), 441-460.

[22]. Velkoska, C., & Tomov, M. (2021). Quality Costs Concept and Measurement – Does A Reaffirmation in A New Direction Needed? *Vision International Scientific Journal, 6*(1), 65-80.

[23]. Jaju, S. B., Lakhe, R. R., & Bhagade, S. S. (2010). Development of empirical quality cost model for a manufacturing industry. *International Journal of Productivity and Quality Management*, *6*(1), 48-70.

[24]. Jaju, S. B., Mohanty, R. P., & Lakhe, R. R. (2009). Towards managing quality cost: A case study. *Total Quality Management*, *20*(10), 1075-1094.

[25]. Chopra, A., & Garg, D. (2011). Behavior patterns of quality cost categories. *The TQM Journal*, *23*(5), 510-515.

[26]. Yang, C. C. (2008). Improving the definition and quantification of quality costs. *Total Quality Management*, *19*(3), 175-191.

[27]. Ittner, C. D. (1996). Exploratory evidence on the behavior of quality costs. *Operations research*, *44*(1), 114-130.

[28]. Kaur, P. (2009). Current Cost of Quality Management Practices in India in the Era of Globalization: An Empirical Study of Selected Companies. *Decision (0304-0941)*, *36*(1).

[29]. Mahmood, S., Ahmed, S. M., Panthi, K., & Kureshi, N. I. (2014). Determining the cost of poor quality and its impact on productivity and profitability. *Management*, *4*(3), 296-311.

[30]. Psomas, E., Dimitrantzou, C., Vouzas, F., & Bouranta, N. (2018). Cost of quality measurement in food manufacturing companies: the Greek case. *International Journal of Productivity and Performance Management*, *67*(9), 1882-1900.

[31]. Sower, V. E., Quarles, R., & Broussard, E. (2007). Cost of quality usage and its relationship to quality system maturity. *International Journal of Quality & Reliability Management*, *24*(2), 121-140.

[32]. Plewa, M., Kaiser, G., & Hartmann, E. (2016). Is quality still free? Empirical evidence on quality cost in modern manufacturing. *International Journal of Quality & Reliability Management*.

[33]. Farooq, M. A., Kirchain, R., Novoa, H., & Araujo, A. (2017). Cost of quality: Evaluating cost-quality trade-offs for inspection strategies of manufacturing processes. *International Journal of Production Economics*, *188*, 156-166.

[34]. Hamrol, A., Kujawińska, A., & Bożek, M. (2020). Quality inspection planning within a multistage manufacturing process based on the added value criterion. *The International Journal of Advanced Manufacturing Technology*, *108*(5), 1399-1412.

[35]. Barouch, G., & Bey, C. (2018). Cost of quality and process model: improving accounting tools for attaining higher environmental efficiency. *Journal of Cleaner Production*, *181*, 192-200.

[36]. Ayach, L., Anouar, A., & Bouzziri, M. (2019). Quality cost management in Moroccan industrial companies: Empirical study. *Journal of Industrial Engineering and Management*, *12*(1), 97-114.

[37]. Obied-Allah, F. M. (2016). Quality cost and its relationship to revenue sharing in supply chain. *Accounting and Finance Research*, *5*(3), 173-189.

[38]. Kambanou, M. L., & Lindahl, M. (2016). A literature review of life cycle costing in the product-service system context. *Procedia Cirp*, *47*, 186-191.

[39]. Sailaja, A., Viswanadhan, K. G., & Basak, P. C. (2014). Analysis of Economics of Quality in Manufacturing Industries. *International Journal for Quality Research*, *8*(1).