

## QUALITY COST FLOWS IN MANUFACTURING COMPANIES

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**Abstract:** Companies have increasingly focused their attention on quality costs. Therefore, raising awareness of this group of expenses is essential. This paper aims to present a survey on the topic of costs of quality management in manufacturing companies in the Czech Republic. This paper opens with a literature review that focuses on the existing cost of quality models and then focuses on empirical research results. Manufacturing companies represent the framework of this research. The research with a total of 159 respondents provides information about the real market situation. The aim was to determine the significance of costs and cost-effectiveness. The study's findings revealed that 73% of organizations quantify their quality costs completely, 21% of companies quantify their costs only partly (external costs), and 6% of companies do not. 36% of surveyed companies (42 companies) that monitor quality costs use some of the recommended models, mainly the PAF model. The research was confirmed by hypothesis 1 that companies that use some type of evidence cost of quality have lower levels of these costs.

### 1 Introduction

Quality is a critical factor that significantly influences a customer's decision to purchase a product from a particular provider. Contemporarily, the market is affected by globalization pressures, which are characterized by an extensive portfolio of products that can be renewed, motivating companies and encouraging them to permanently improve their level of production and find new competitive advantages. Cost versus quality is the everyday question for the management of an organization. Everybody wants the best products but at the lowest price. However, it is complicated to find a boundary between minimum cost and maximum quality [1]. The company must always try to improve the quality of its production while at the same time striking a balance between the best quality and extraordinary costs for the company. [2]. Many studies have examined the measurement of quality costs and the quality level. Behmer and Jochem [3] claimed that the annual costs of poor quality amounted to approximately 15% of sales. Chiadamrong [4] estimated their proportion is around 10% of production costs and Evans and Lindsay [5] declared that costs of quality care from 20% - 40% of total costs in the company. These statements confirm that the high proportion of quality costs in the structure of overall company costs confirms that quantification of these costs cannot be ignored and requires an interdisciplinary approach.

The following chapters describe quality definitions and the different approaches and benefits of monitoring quality

costs. The next part focuses on the research methodology and presentation, leading to the conclusion.

#### 1.1 Definition of cost of quality

The first mention of quality costs dates back to 1951, but Juran states that there are different meanings for the term quality costs. It should be pointed out here that there is no clear definition for the term "cost of quality" Some people may see the term as a cost incurred in the separation of management [6,7]. From the perspective of quality-related costs, costs incurred due to coordination activities are hidden costs of non-quality. If these costs are excluded from the costs of quality, it systematically underestimates the total costs of quality[8]. Authors Evans and Lindsay [5] argue that in the case of costs, it depends on the actual situation of the business and its operations. According to Ireland [9], the term quality cost must be properly explained and understood in order to maintain optimal functioning and improvement of product and service quality. Some authors [5,7,11,12] describe quality cost as a set of three main categories: costs of failure (internal and external costs), evaluative costs and preventative costs. These descriptions are explained in overview Table 1.

#### 1.2 Classification of cost of quality

Several tools and methods could be used for the costs of quality analysis. The most common models are the PAF model.

Table 1 Descriptions of quality costs

Type of costs of quality	Definitions
Insider costs	These costs are associated with defects that tend to be detected before they are delivered to the customer, making it impossible to satisfy the customer's needs [7].
Externalities	These costs are often discovered by customers and are reported as product defects [10].
Assessment Costs	These costs are aimed at meeting quality and performance requirements and are also associated with ratings, revisions and verifications [11].
Prevention Costs	These costs are set to keep breakdown and valuation costs as low as possible.

### 1.2.1 The PAF model

The measurement of quality costs was first done by Dr. Armand V. Feigenbaum in 1956. He divides the costs of quality into three categories [12]. These are the costs of prevention, evaluation and non-conformance.

The British Standard Institution as well as the American Society for Quality Control (ASQC) have adopted this breakdown and incorporated it into their standards. In production and services, this model is the most used [13]. According to author *Laura* [14], it is possible to take advantage of this model to obtain easier data for processing and time lag. Another benefit is the fact that with the proper management of quality costs, the cost of prevention and cost of appraisal have an impact on the reduction of the cost of failure and the overall cost of quality [15-18].

### 1.2.2 The PCM model

The PCM model brings only two costs categories: Costs of compliance and non-compliance costs. According to Ireland [9], these are categorized as costs of planning, control processing, verification and controls and so on. Scrap, reworking and guarantee service, etc., are in the secondary classification. In the eyes of Goetsch and Davis [19], the costs of conformity cover the money for the products or services supplied in the most efficient way following the standard requirements.

It is a situation in which every activity is executed for the first time in conformity with the requirements. Not all costs of non-conformance are the costs that are linked with failures.

It is possible to apply this process model to any process, but it is necessary to identify the key steps process and the following parameters [19]. According to the authors Pires

et al. [20], this approach follows the flow of activities in various departments of the company, while the traditional approach focuses on the activities of specialized departments. Lari and Aslanni [21] use the idea that using the cost of quality as a measure of the performance of the operating processes leads the organization to better performance results. The benefits of this model can be seen as the fact that exact costs are allocated to the process and that a specific person is established as responsible for the mistakes in the process [22]. This model allows the underestimated processes to become opportunities for improvement, helps management manage processes, allows for systematic management processes and improves customer service activities [21].

### 1.2.3 COPQ Model

This model is based on the assumption that non-compliance with customer requirements always causes producers considerable economic losses [23]. The uniqueness of this model is that it only records non-productive losses and thus neglects efficiently spent resources [24]. It monitors the cost in these four categories: cost of internal defects, cost of external defects, the cost associated with investment and the use of opportunities and costs associated with environmental damage. Very often, there is no evidence that would be able to track items from the last two groups [13].

## 1.3 Quantification of costs of quality

Cost of quality information helps the organization's management to evaluate its important quality issues and identify the most significant opportunities to reduce these costs [25]. Last but not least, it helps the organization to evaluate success in achieving quality objectives. Many authors have described quality costs as a necessary process for management in companies [26]. This process brings many benefits to businesses, such as achieving a higher level of product and service quality, reducing the cost of products and services, greater customer satisfaction [27] and improvements in efficiency, effectiveness and quality management system, including financial performance [28]. In addition, it reduces the number of complaints, lowers the cost of failure and increases sales volume [29]. Other benefits include the ability to report a complete overview of the company's quality costs, classification and analysis of associations, costs for different levels of management and assistance for the development of tracking methodologies. [30]. Although it is shown that quality cost tracking has many benefits, it must be said that this concept is not being given sufficient attention [31]. The authors Sower and Quarles [16] and Kiani [15] provide evidence in their work that monitoring quality cost is not as widespread as expected in the world. The concept of quality cost management enterprises was not accepted despite the fact that this indicator should be included among business performance indicators [32]. Reasons for the problem are the lack of standardization and an inadequate

understanding of the concept principles [33]. The next type of problem could be the fact that the relationship between the people in the organization is such that costs can not be discussed openly without fear of punishment [34]. In an organization where the atmosphere is open and problems are communicated without fear and punishment is, the quality system more effective [33-34]. Authors Mantri and Jaju [35] draw attention to the fact that a lot of companies use their own methodology for evaluation and that the data was collection still manually although technologies are implemented.

## 2 Methodology

The aim of the research was to find out the level of implementation of quality cost control in manufacturing companies of the Czech Republic. In the first step, the authors performed a quantitative analysis to get fundamental knowledge about the current situation. Based on the results of theoretical research, the following hypotheses were defined:

- H1: Companies that quantify quality costs and use for it some systems have lower costs of quality than others.
- H2: Characteristics of companies that quantify quality costs are different compared to companies that do not quantify quality costs.
- H2a: Large companies quantify quality costs to a greater extent than small and medium-sized companies.
- H2b: Multinational companies quantify costs more than domestic companies.
- H2c: Companies with mass and serial types of production quantify costs to the extent that companies with piece types of production.
- H3: Companies see the biggest problem with monitoring costs of quality in inappropriate methodology.

Questionnaire-based research was used to obtain data for evaluating the above-mentioned hypotheses. Besides the initial basic information and classification questions

(industry, size of the company, type of production and owner structure), the questionnaire includes five questions related to the level of cost of quality management and the next four questions describing the results of this system in the companies. The type of questions is shown in Table 2.

Data were collected through an electronically distributed questionnaire. A total of 159 manufacturing companies from different industrial areas participated in this survey. The questionnaire was sent to 1412 companies, and the effective rate of returned questionnaires was 11.3% which is considered satisfactory. The questionnaire was designated to the representatives of the quality departments as the most known persons in this process in the company. The structure of respondents is described in Figure 1. This figure represents the structure according to the European classification of economics activities (NACE classification)

Table 2: Type of questions

Number	Question
Q1	Interest in monitoring costs of quality
Q2	Costs monitoring using the model
Q3	Type of using models
Q4	Type of monitored costs categories
Q5	Type of monitored current costs
Q6	Level of costs of quality
Q7	Improvements in specified areas
Q8	Advantages and disadvantages
Q9	Obstacles and opportunities

Source: Authors

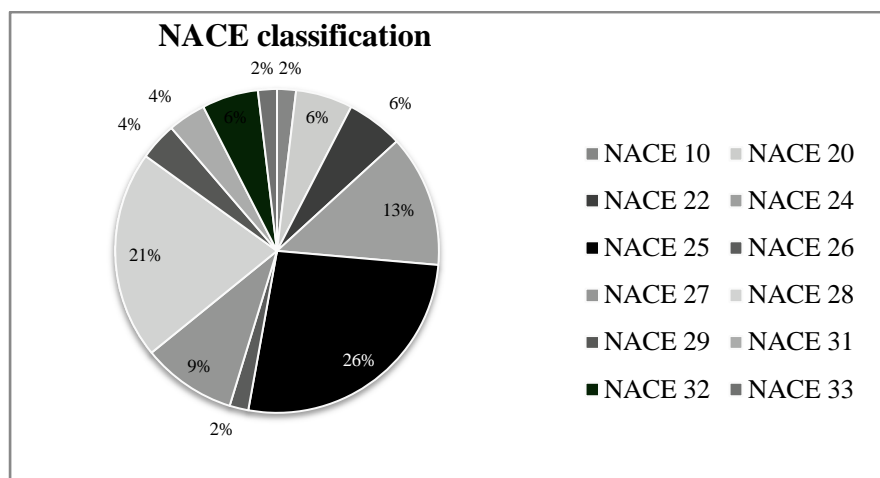


Figure 1 Structure of respondents

Source: Authors

The following Table 3 shows additional basic information on the composition of respondents. Most of the companies in the sample are small and medium (62.2%), while large companies account for 37.8% of the sample. More than half of the companies (53.5%) have a foreign majority owner, while only 46.5% of companies have a domestic owner. Almost of companies is with mass or serial type of production (59.7%) while companies with piece type of production is 40.3%.

Table 3 Sample description

Characteristics	Variable	Companies	%
Company size	Small and medium	99	62.2%
	Large	60	37.8%
Business segment	Domestic majority owner	39	24.5%
	Foreign Majority owner	49	30.9%
	Subsidiary company - foreign majority owner	36	22.6%
	Subsidiary - domestic majority owner	35	22.0%
Type of production	Piece production	64	40.3%
	Mass production	20	12.5%
	Serial production	75	47.2%

Source: Authors

In order to test the research propositions, several statistical methods were used. One of the applied methods was the t-test for independent samples. This test was deployed to test the differences in the characteristics of the costs of quality. The second test was the Chi-square test. This test was used to test the differences between companies that quantify and those that do not quantify costs, considering their size, type of production and ownership structure. The main goal of this study is to analyze the situation in our market and to understand better the main barriers influencing the management of costs of quality.

### 2.1 Data

The quantification of quality costs was observed on a nominal measuring scale. The results show that 73% of companies quantify their quality costs completely, 21% of companies quantify their costs only partly (only external costs), and 6% of companies do not. 36% of surveyed companies (42 companies) that monitor quality costs use

some of the recommended models. The other companies (75 companies) do not use any of these models and only follow some categories or use their own system. If a company already uses one of the models, it is a PAF model (69% of respondents - 29 companies).

### 2.2 Evaluation of the first hypothesis

In order to test the first hypothesis, the t-test procedure was applied. The results of the t-test used to test the existence of statistically significant differences in the characteristics of the costs of quality depending on the decision to quantify the costs of quality are shown in Table 4. In the part of the paper, the level of quality was observed through dimension costs of quality. The respondents were asked to rate their level of costs of quality in their companies. These characteristics were measured on a five-point Likert scale.

According to the results presented in Table 4, there is a statistically significant difference in the level of costs of quality depending on whether the company quantifies quality costs ( $p < 0.005$ ). By comparing these two groups of companies, it is evident that companies that quantify costs of quality gave significantly lower costs of quality ( $x = 4.147$ ,  $s = 1.061$ ) than those that do not quantify quality costs ( $x = 3.326$ ,  $s = 1.307$ ).

Table 4 T-test results

	Quantification	n	Mean	s	t test	p - value
Quality costs	YES	117	4.147	1.061	3.0096	0.003
	NO	42	3.326	1.307		

Source: Authors

### 2.3 Evaluation of the second hypothesis

The hypothesis number 2 a) states that large companies quantify costs of quality to a greater extent than small and medium companies. It is expected that large companies to be more concerned with monitoring and evaluating the cost of quality. The Chi square test was used to test differences among companies that quantify and those do not quantify costs of quality. The significance level was selected at 0.05. The results are shown in the Table 5. The Chi square test shows interesting results. In the total number of companies that quantify costs of quality 53.9% are small and medium companies while 46.1% are large companies. Therefore our hypothesis number 2 a) is not rejected at level 0.05.

Table 5 Chi square test results

	Small and medium companies	Large companies	Total	Chi square test
Quantify quality costs	63 (53.9%)	54 (46.1%)	117 (100%)	Chi square = 13.3585 p value = 0.000257
Not quantify quality costs	36 (85.7%)	6 (14.3%)	42 (100%)	
Total	99 (62.3%)	60 (37.7%)	159 (100%)	

Source: Authors



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Hypothesis number 2 b) states that multinational companies quantify costs of quality to a greater extent than domestic companies. The Chi-square test was used to test differences between companies that quantify and those that do not quantify costs of quality. The significance level was selected at 0.05. The results are shown in Table 6. Of the total number of companies that quantify costs of quality, 57.3% are multinational companies, while 42.7% are domestic companies. The chi-square statistic is 2.5786. The p-value is 1.10832. Therefore our hypothesis number 2 b) is rejected at the level 0.05.

Table 6 Chi square test results

	Multinational companies	Domestic companies	Total	Chi square test
Quantify quality costs	67 (57.3%)	50 (42.7%)	117 (100%)	Chi square = 2.5786 p value = 1.10832
Not quantify quality costs	18 (42.9%)	24 (57.1%)	42 (100%)	
Total	85 (53.5%)	74 (46.5%)	159 (100%)	

Source: Authors

Hypothesis number 2 c) states that companies with mass and serials types of production quantify costs of quality to a greater extent than companies with piece type of production. The Chi-square test was used to test differences between companies that quantify and those that do not quantify costs of quality. The significance level was selected at 0,05. The results are shown in Table 7. The Chi-square test shows these results. Of the total number of companies that quantify costs of quality, 63,2 % are the serial and mass type of production, while 36,8 % are piece type of production. The chi-square statistic is 2.2554. The p-value is 0,13315. Therefore our hypothesis number 2 c) is rejected at the level 0,05.

Table 7 Chi square test results

	Piece type of production	Serial and mass type of production	Total	Chi square test
Quantify quality costs	43 (36.8%)	74 (63.2%)	117 (100%)	Chi square = 2.2554 p value = 0.13315
Not quantify quality costs	21 (50%)	21 (50%)	42 (100%)	
Total	64 (40.3%)	95 (59.7%)	159 (100%)	

Source: Authors

The Chi-square test shows some exciting results. Of the total number of companies that quantify quality costs, 53.9% are small and medium-sized companies, while 46.1% are large companies. However, it could be said that 90% of large companies quantify quality costs. A similar result is visible in multinational companies, where 78.9% of companies quantify quality costs. This result was expected considering the fact that large and multinational companies have more significant resources than small and medium-sized companies. Furthermore, it is evident that 63.2% of the total number of companies that quantify quality costs are companies with the serial or mass type of production, while 36.8% are companies with the piece type of production.

From the questionnaire survey results, it is clear that a total of 117 (73%) companies are involved in quantifying quality costs. Table 8 lists the problems that prevent more comprehensive monitoring of quality costs in different firms.

Table 8 Problems

Problem	Mass and serial type of production	Piece type of production	Total
Reluctance to cooperate	16	16	32
Inappropriate methodology	21	7	28
Time-consuming cooperation	14	7	21
Insufficient software support	13	8	21
Little management support	10	3	13
Subjectivity of costing	0	1	1
Conceal nonconformities	0	1	1
Total	74	43	117

Source: Authors

### 3 Result and discussion

To sum up the findings from our testing strategy. On the one hand, the study fulfilled expectations in the form of original assumptions. Large and multinational companies give more attention to this issue than small and domestic companies. This result was expected because large and multinational companies have more significant resources than small and medium-sized companies. On the other hand, these numbers were not as different as the study's authors initially anticipated. Detailed results are given in chapter four. The study also found unexpected conclusions

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that refute the claims of other authors. The research of Amiya Kumar Pattanayak [36] declares that the cost of quality management is not a widely used concept. The newest research by Elizondo [32] states that companies do not pay much attention to this issue because they are not sufficiently acquainted with this issue. However, the opposite was the result of our study. 73% of all surveyed companies are engaged in this issue which means that companies use a system to monitor quality costs (either have their internal rules or use some of the recommended models). If the company use some type of model, it is the PAF model. This model is a widely used model because it is applicable in most companies [37].

However, on the other hand, only 69% of companies use it for monitoring quality data. The research was confirmed by hypothesis 1 that companies that use evidence cost of quality have lower levels of these costs. Research has shown that large and multinational companies are the most involved in monitoring and evaluating, which was expected. However, in all cases, similar obstacles can be identified. These include in particular reluctance to cooperate, inappropriate methodology and time-consuming data collection. It is necessary to develop suitable approaches and methods to reduce the burden of data collection. This would be a big challenge for research.

#### 4 Conclusions

In the introduced paper, the present state of the subject matter was analyzed on the basis of the literature review with a focus on the core of the costs of quality management. Consecutively via the questionnaire survey, the level of costs of quality management in the manufacturing companies was researched. The benefit of this study was mapping the current situation of cost of quality management in the environment of the Czech Republic. Based on 159 respondents, the study gives an insight into companies and how quality costs are related. It can be seen that companies increasingly make an effort to determine quality costs to improve the processes in the company. It can be identified the similar type of problems with the related costs of quality. These include, in particular, the reluctance to cooperate, inappropriate methodology and time-consuming evaluation.

The topic of further research will be a study of quality costs in companies. At the same time, this study showed that companies are involved in quality, but many of them do not use any of the recommended models for evaluation. It is also a question of further exploring whether companies quantify these costs correctly. Knowing the quality costs is the basis for further management decisions for each business and must be based on the correct and relevant data to help companies make these decisions. For most quality costs, it is possible to eliminate them by using an effective and efficient quality management system. Companies should do a systematic and comprehensive financial analysis of various processes. While all people know the

rule stating that it is better to do things right from the first time, they do not know how much better it is.

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