MANAGING THE COSTS OF QUALITY IN A CZECH MANUFACTURING COMPANY

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Abstract

One approach to increasing the quality of products and services in companies is the application of a management system of quality costs. This tool is applied to improve the economic results in the company and is considered also as a tool that identifies key areas where the company should direct investment into quality improvement programs. The following article focuses on markets for optical equipment, using action research. The chosen Czech company's management approach included the implementation of cost management, with the aim of reducting costs of prevention and costs of appraisal and failure. This approach is known as the PAF model. The implementation of the PAF model revealed the true cost structure of quality costs and their real evaluations over time, in this case the period of 2010 – 2014; it also identified key areas for improvement.The greatest potential for improvement was hidden in a category of internal failure costs. In this category the annual costs amount to an average of 7,174 % of sales during the period. In the last part of the article, the costs of quality were analyzed against the sales of company (including material losses). Ultimately, the hypotheses in sections 4.3.1 and 4.3.2 were validated and based on these analyses the current state of the process was assessed and recommendations to streamline were presented.

Keywords: *Cost of quality, Management cost of quality, PAF model, Czech Republic*
JEL: *M11, L60, L69*

Introduction

Quality is one of the key factors that has a major influence on the customer decision to purchase a provider of a particular product. The concept no longer just refers to the high quality of products, it also encompasses quality in terms of service delivery, timeliness, after sale services and the production process itself (Ahmed Al Dujaili, 2013). Current globalization pressures, given a wide portfolio of products on the market that can be substituted for each other, is motivating for a company and leads the company to continually seek to raise the level of its production and thus gain a competitive advantage. The company is constantly striving to improve the quality of its production, but that must be a compromise between the right quality and costs which the company added. Quality cost management aims to create a high quality and high performance product or service that meets and exceeds the customers expectations (Ahmed Al Dujaili, 2013). These costs should be used in the most effective manner. So that the company can assess this effectiveness, it uses tools designed to manage the cost of quality. The literature provides many models and approaches to manage the costs of quality (Schiffauerova and Thomson, 2006; Arabian, 2013; Mizla and Puzlo, 2012), but none of these methods and models are standardized. This complicates the application of these methods and models in practice. According to Campanella (1999) a standard applicable to all types of businesses cannot be created. It must always depend on the specific situation and needs of the company.

This paper is focused on the application the cost of quality management in one company focusing on optical products. The main objectives of this paper is

demonstrate that attention only to monitoring costs without proper evaluation of the relative quality in a complex context is not sufficient thereby it also demonstrates the importace of managing the costs of quality. Firstly the system of the cost of quality management is described. In the next part the methodology of the research is showed followed by the results and recommendations. The final part is focused on the discussion and conclusion.

1.Literature review

1.1. Costs of quality

The concept of quality costs originated in 1951 (Pyzdek and Keller, 2013). At that time, the reporting of costs was limited only to inspection and testing and other items were included in overhead costs. When managers started to deal with the full scope of the cost of quality, they were suprised. It appeared that the costs of quality were doubled from 20 % to 40 % (Evans and Lindsay, 2008). Juran (1998) argues that the concept costs of quality has different meanings. Some people perceive it as the costs of poor quality. Others take this term to mean costs incurred by the work of the department of quality management. Mizla and Pudlo (2012) further Juran's opinion and argue that there is no general definition that could specify costs of quality. They justify this by holding that costs depend on the specific situation in the company and its own processes. According to the Ireland (1991), for the proper functioning and improvement of the quality of products and services in any company, term costs of quality must properly be explained and understood. Wood (2013) highlights that understanding the costs of quality helps show how effectively to integrate processes with customer needs, and brings the balance in the value chain that sustains the global economy. Many authors (Juran, 1998; Campanella 1999; Evans and Lindsay, 2008; Arabian, 2013) define the costs of quality as the sum of three main categories: costs of failure (internal and external costs), costs of appraisal and costs of prevention. The meaning of understanding these costs to all the authors is the same, however each author uses a different definition for its explanation.

Tab. 1: Opposing views of the costs of quality

JURAN	GUPTA AND CAMPBELL
Internal costs – These costs were identified before the delivery to the customer and they are associated with the failures that prevent satisfy customer needs. **External costs** – These costs are declared like weaknesses on the products and they are identified by customer. **Appraisal costs** – These costs are incurred determine the degree of compliance with customer requirements. **Costs of prevention** – These costs are incurred to keep the costs of failure to a minimum (Juran, 1998)	**Internal costs** – These costs arise from the connection with production of defective products. They are discovered before the delivery to customer. **External costs** – These costs are associated with products of unacceptable quality. They are discovered after the delivery to customer. **Appraisal costs** – These costs are incurred for the detection of product compliance with the quality requirements. **Costs of prevention** – The company invests these costs to reduce the cost of failure. (Gupta and Campbell, 1995)

BS 6143	CAMPANELLA
Costs of prevention – These costs are determined to reduce the failure costs and the appraisal costs to the minimum. **Costs of appraisal** – These costs are associated with ensuring compliance and fulfillment of the requirements of the customer. These costs exclude the costs of rework or reinspection failure. **Internal costs** – These costs are associated with failure and are identified before to delivery to the customer. **External costs** – These costs are associated with failure and are identified after the delivery to the customer. (BS 6143, 1990)	**Costs of prevention** – These costs are invested to all activities regarding preventive measures. **Costs of appraisal** – These costs are associated with the measurement, evaluation and audits to ensure compliance with the quality standards and with the requirements of performance. **Costs of failure** – These costs are the results of the products or services which are not in conformity with the needs of customers (internal and external). (Campanella, 1999)

Source: Author

1.2. Quality cost models

There are a few models and methods that can be used to analyze the costs of quality. The traditional model is the model PAF which groups costs into three basic categories: costs of prevention, appraisal and failure. The last category is divided into two more categories: internal failure and external failure. (Juran, 1998) Today, there are other types of models. Arabian (2013) identifies the PCM model which is used by a lot of companies. Srivastava (2008) adds still others: Crosby's model, COPQ or ABC. Mateides (2006) sees the main advantages of these models as able to depict with complexity the costs of quality of the enterprise. These models enable classification and linkage analysis with one other, provide an overview of the costs for various levels of management and assist in the development of methodology for monitoring and evaluation of costs. Through these models we can compare other departments across the group.

1.2.1. PAF model

Dr. Armand V. Feigenbaum was the first who developed the concept of measuring the costs of quality in 1956. The principle was oriented to categorize costs into three main section: prevention, appraisal and failure. (Arabian, 2013) This breakdown was adopted by the British Standard Institution (BSI), the United States incorporated it into their standards in BS 6143 and Part 2 via ASQC (American Society for Quality Control). This model is widely regarded as the most widely used for manufacturing and services in practice. (Mizla and Puzlo, 2012)

1.2.2. *PCM model*

PCM model is divided into only two categories: costs of conformity and costs of nonconformity. Ireland (1991) classifies in the category of conformity as the costs of planning, process control, testing and validation, audits, etc. In the second category are included the costs of scarp, rework, warranty service etc. According to the authors Goetsch and Davis (2014) conformity costs include amounts for the provision of products or services to the required standards of a particular process in the most

effective manner. This is the situation where each activity is carried out in accordance with the requirements for the first time. The cost of nonconformity are the costs which are associated with failure. The process model can be applied to each process but it must be identified by the key process steps and parameters that are monitored.

2. Research methodology

This study was prepared in a company which produces optical products. Although the company has a dominant market position, it is under enormous pressure to reduce product prices because the market conditions are rigorous. This situation demands that therefore great attention be paid not only to technical side but also to the economical side. The company recognizes the importace of cost of quality management and they deal with them carefully and in the long term. This system is considered to be the pursuit of continuous improvement. This pursuit has resulted in more efficient processes, reduced costs and increased productivity. In the company quality is considered one of the decisive factors of stable economic growth. It improve the quality of the programs and constantly streamlines it. For the successful implementation, a project team was created which was composed of representatives of the departments of production, finance, accounting, quality, and even the academic sector (as a consulting component). After an agreement between the project team and the company's management, it was decided that one of the financial management models of quality costs would be implemented in the company: the PAF model.

The project was very demanding from the perspective of data collection. The required costs were collected via interviews with management representatives, analyses of financial reports and information from company statements of other internal company records and the information system. However the company records certain items of expenditure quality (cost of irreparable defects, costs of customer complaints, etc.). These data are not registered in any complex system, do not include all sums of costs that really belong into the desired category and are not assessed in relation to the whole. Although they are monitored, they have no meaningful value for the company and it is impossible to manage the costs or optimalize the costs on their base. At the least the model also included cost items which were established on the basis of a qualified estimate by representatives of the company's management based on its experience and also data from previous periods.The main objective of the project was the implementation of the monitoring of four groups of costs according to the PAF model between 2010 and 2014. The model was implemented over a longer period of time precisely because the company had a comprehensive view of the cost of quality over time and that implementation has brought a new perspective to understanding these items to reveal new key areas on which the program can improve the quality of enterprise focus. Last but not least the aim was to demonstrate the fact that only appropriate monitoring of quality costs can demonstrate the importance of using this tool.

For the evaluation data obtained after the implementation of the PAF model the graphical evaluation methods and the descriptive statistics methods – relative and absolute frequency were used. To be draw conclusions from implementation was necessary to make several next analyses. The first was Pareto analysis. It was oriented on the internal failure cost. Further analysis was statistical Regresion analysis which identify the relationship between costs of failure and cost of prevention and the last analysis was Friedman test. This test verify the following hypothesis.

H_1: Between the years which the company has the same level of costs in the category of prevention.
H_2: Between the years 2010 – 2014 the company has the same level of costs in the cost category for evaluation.

3. Results

The company impemented the PAF model. This model is oriented on the three categories: the costs of failure, the costs of prevention and the costs of appraisal. The concrete items are shown in the tables one to five in the annexes to this article. These items were classified into categories after the appointment of the project team and it respects the methodology recommended by the PAF model. The results of the implementation are summarized in the tables in the annexes and they are shown by the percentage proportion of each unit in relation to the relevant category. For example: from all the costs of internal failure was 35, 250 % of the costs spent on the loss of irreparable defects in 2010. The next table number 2 shows the total costs of quality in the period from 2010 to 2014.

Tab. 2: Costs of quality

	2010	**2011**	**2012**	**2013**	**2014**
Costs of prevention	4,077%	3,763%	3,870%	3,917%	3,611%
Costs of appraisal	44,419%	41,371%	42,715%	43,757%	44,626%
Costs of failure	51,505 %	54,866 %	53,415 %	52,326 %	51,763 %

Source: Author

These data have no predictive value. In order to be able evaluate the data without any disortion and so that they can be evaluated based on their conclusions, it is necessary that the data be evaluated further with the suitable base ratio (Campanella, 1999). The project team was chosen as a suitable base of company sales. The evaluation of quality costs to sales is shown in the following table 3. Data are evaluated by a percentage of the relevant category to total sales of the company in the period from 2010 to 2014.

Tab. 3: Total costs of quality to sales

	2010	**2011**	**2012**	**2013**	**2014**
Total costs of quality / sales	**18,93 %**	**16,61 %**	**18,27 %**	**18,11 %**	**18,12 %**
Costs of prevention / sales	0,72 %	0,59 %	0,67 %	0,67 %	0,62 %
Costs of appraisal / sales	7,83%	6,49 %	7,36%	7,51%	7,65 %
Costs of internal failure / sales	7,15%	6,91%	7,51%	7,17%	7,13 %
Costs of external failure / sales	1,97 %	1,73 %	1,70 %	1,75 %	1,73 %

Source: Author

4. Discussion

4.1. Analysis of costs of quality to sales

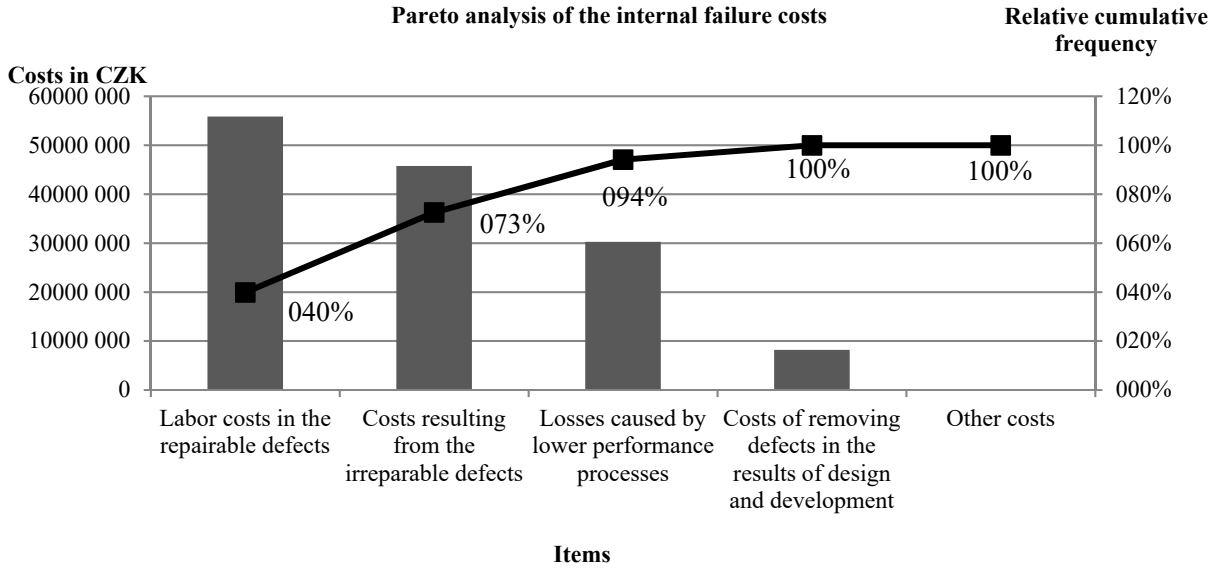
According to the data presented in table number 3, the total costs of quality to sales are arround 18 % annually. The only exception is 2011 (16,61 %). This year the

company had sales decline which it was accompanied by the decrease in costs in each category. However according to experts (Crosby, 1979; Hanse let al., 2009) the optimum of costs of quality due to sales should be 2 - 4%. A high percentage of quality costs compared to sales (about 18 %) should alarm the company that they should be more concentrated about the quality of products, processes and performance of the entire system as a whole. The weakest link and the greatest potential for optimalization is the category of internal failure costs, specifically the costs of the repaired defects and the costs of irreparable defects which reach of around yearly average 7 % of the total costs of quality related with respect to sales. One positive aspect here is the reality that internal failure costs are lower by comparision to external failure costs. External failure costs are very dangerous for the company because the high costs in this category can lead to loss of customers to the worsening corporation reputation.

4.2. Analysis of costs due to material wastage

Internal failure costs include the biggest cost item (see table 1 in Annex Article). In order to develop its evaluation, it is necessary that this category is submitted to further analysis. Due to the constantly changing and evolving conditions in production, the analysis was prepared for the year 2014, where the latest information about production are available. To reduce the costs of internal failure was used the Pareto analysis shown in the following figure.

Fig. 1: Pareto analysis of the internal failure costs

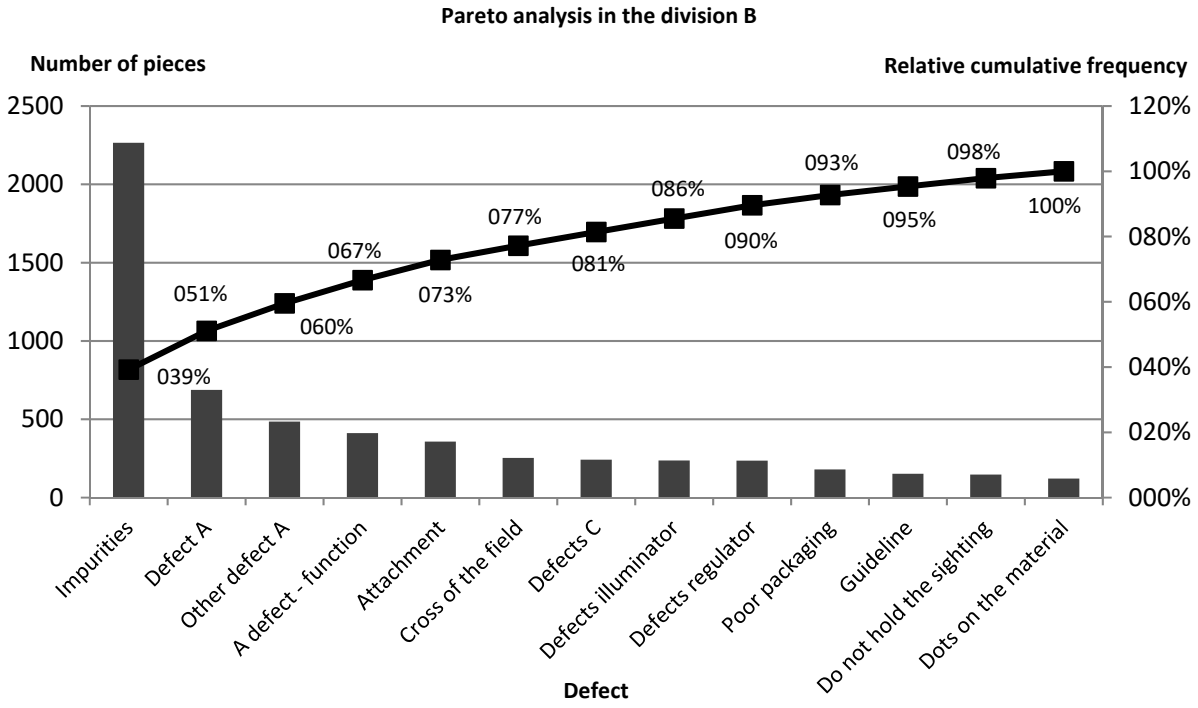


Source: Author

As you can see in figure number 1, almost 80% of the total costs of internal failure are due to: the costs of repaired defects and the costs of irreparable defects. This company is a larger company and it is divided into division A, division B and division C. After consultation with the project team, the detailed analysis was oriented on division B. This division was chosen because it assembles parts of division A and division C. This division brings the company the greatest added value. In this division was applied the Pareto analysis and the results are shown in the next figure. As is

visible, the biggest problems are impurties and defects from division A. The next analysis in the form of an Ishikawa diagram, where it is shown that the most likely cause of impurties of the material is the bad deburring of the material. Deburring process takes in the company in various ways. The first can be deburring done by CNC machine. The second manner is the removal of the needles at the end of the material by rolling in the beat (steel or ceramic). The third way can be cooled material. According to the attachment of the project team, it was suggested to the company that it invest in a new machine that would perform material deburring in division B. The costs associated with the incorrect deburring of one piece were estimated at 733 CZK. By properly deburring correctly the first time, the company save almost 3 325 179 CZK annually. The return on investment would be 5,3 years. The average life of the machine is 15 – 20 years. This investment could certainly pay off for the company.

Fig. 2: Pareto analysis in the division B



Source: Author

4.3. Analysis of the total costs of quality

The management of the company does not deal with the processes of the cost of quality. The PAF model deal with the costs of failure, appraisal and prevention. The category of appraisal and prevention are considered efficient use of resources. The category of failure costs is then classified as a loss for the company. (Nenadál, 2002). For this purpose, it could therefore be concluded regarding the overall total cost of quality that it is necessary to verify the following hypotheses that focus only on costs that are spent effectively: appraisal costs and the costs of prevention.

4.3.1 Costs of prevention

This category can be determined to verify the following hypothesis:

H1 = Between the years which the company has the same level of costs in the category of prevention.
This hypothesis was tested through the Friedman test and the program R. The results are shown in the following figure.

Fig. 3: The results of verify H1

```
        Asymptotic General Symmetry Test

data:  Naklady by Rok (2010, 2011, 2012, 2013, 2014)
         stratified by Naklad
maxT = 1.5492, p-value = 0.5303
alternative hypothesis: two.sided
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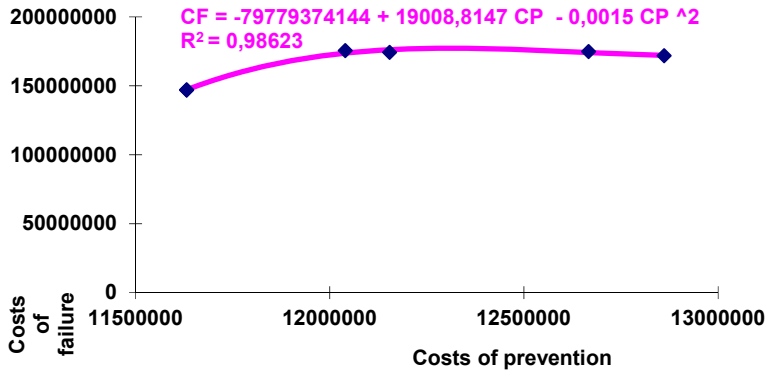
Source: Author

The results show that there is not enough evidence to reject the hypothesis of compliance costs in individual years. Further statistical analysis can not be performed because the cost structure is the same in all years (2010-2014). The category of prevention can still help us examine the relationship between the cost of prevention and cost of failure.In the regression analysis the costs of prevention and the costs of failure are compared. Horizontal axis x shows the costs of prevention and the costs of failure is examined on the vertical axis y. We verify whether the dependent variable (explained) is depended on the x – the costs of prevention.If the cost of quality in a company is managed correctly then it adds value to the cost by preventing a decline in the cost of failure.To verify the relationship between these two categories we used regression analysis processed in the program XL Statistics.

Fig. 4: Regression analysis in the program XL Statistics



Source: Author

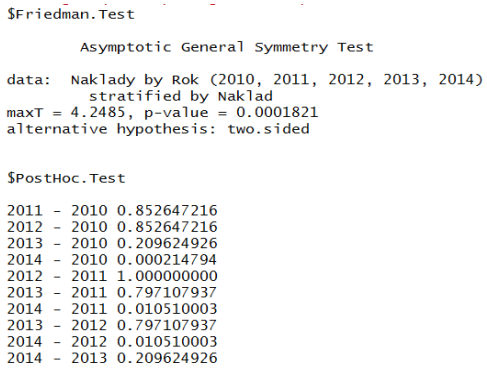
The above illustration represents a regression trend between the cost of prevention and cost of failure. Based on the results, we can say that the costs of prevention and the costs of failure to show strong and statistically significant negative relationship at the 95% confidence level.

4.3.2. *Costs of appraisal*

With this category can be determined to verify this hypothesis:
H2 = Between the years 2010 – 2014 the company has the same level of costs in the cost category for evaluation.

To verify the above hypotheses were also used Friedman test carried out in the statistical program R.

Fig. 5: Verify H2 in the program R



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$Friedman.Test

        Asymptotic General Symmetry Test

data:  Naklady by Rok (2010, 2011, 2012, 2013, 2014)
        stratified by Naklad
maxT = 4.2485, p-value = 0.0001821
alternative hypothesis: two.sided


$PostHoc.Test

2011 - 2010 0.852647216
2012 - 2010 0.852647216
2013 - 2010 0.209624926
2014 - 2010 0.000214794
2012 - 2011 1.000000000
2013 - 2011 0.797107937
2014 - 2011 0.010510003
2013 - 2012 0.797107937
2014 - 2012 0.010510003
2014 - 2013 0.209624926
```

Source: Author

On the results of Friedman test, we can claim that we reject the hypothesis about the same level of costs between the years, and may perform post hoc test. This post hoc test showed that the rejection of this hypothesis was most apparent in difference in cost for the years 2010 - 2014, 2011 - 2014 and 2012 - 2014. It is therefore declared that the year 2014 for the company in terms of cost was the most important year as concerns changes in the cost structure.

Conclusion

In the company was applicated management system of quality costs. This tool is applied to improve the economic results in the company and is considered also as a tool that identifies key areas where the company should direct investment into quality improvement programs. In the company was implementated the PAF model which demonstrated real progress and regarding the cost of quality for the period from 2010 to 2014. The greatest potential for improvement was in the category of internal failure, which was also analyzed further. Based on these analyses against the sales of the process was assed and recommendations to streamline were presented. The company was advised to first start dealing with this category and gradually try to eliminate all the causes of problems and not just in Division B but gradually throughout the company. The next step would be legal and management costs in this category. During the next period the company should then start to drive additional categories of quality costs and according to recommendations (Nenadál, 2004) so that the cost of prevention increases an effect which will show further gradual reduction in the annual cost of failure. The cost of the evaluation should then report annually about the same or slightly rising trend. The main objective of this paper was to demonstrate that attention only to monitoring costs (without proper evaluation of the relative quality in a complex context) is not sufficient thereby it also demonstrates the importace of managing the costs of quality. Not only this case study but also studies by other authors (Ahmed Al-Dujaili, 2013; Schiffauerova, 2006) demonstrate that the findings suggest that this impelementation improves firm performance as such more companies should look at the implementanion of cost of quality as a visible alternative to improve their bottom lines of quality. This results show that the implementation of cost of quality management plays an important role in the company.

Authors are thankful to the Internal Grant Agency of FaME TBU No. IGA / FaME / 2016/004 Economics of Quality and Its Impact on the Efficiency of Business Processes and Their Parameters in Czech Enterprises for the financial support to carry out this research.

Annex Article

Tab. 1: Costs of internal failure

	2010	2011	2012	2013	2014
Loss of irreparable defects	35,250%	32,324%	35,114%	35,135%	32,645%
Costs of labor to repair correctable defects	42,977%	39,874%	39,349%	37,674%	39,872%
Costs of removing defects in the results of design and development	5,323%	5,168%	4,375%	5,100%	5,841%
Costs for special tools and equipment nedded to repair defective products	0,011%	0,009%	0,009%	0,010%	0,009%
Losses incurred depreciation of materials and inventory at their rough handing	0,012%	0,010%	0,009%	0,010%	0,009%
Losses on customer property	0,011%	0,010%	0,009%	0,009%	0,009%
Losses due to nonconformance with the planned launch of new production processes	0,010%	0,009%	0,008%	0,010%	0,009%
Damages and shortages	0,028%	0,014%	0,022%	0,028%	0,024%
Losses caused by lower performance of processes	16,379%	22,582%	21,104%	22,024%	21,582%

Source: Author

Tab. 2: Costs of external failure

	2010	2011	2012	2013	2014
Costs of complaints	95,749%	96,367%	95,917%	96,236%	96,006%
Cost for seeking alternative buyers	4,251%	3,633%	4,083%	3,764%	3,994%

Source: Author

Tab. 3: Costs of appraisal

	2010	2011	2012	2013	2014
Costs of market research and defining requirements for production	2,829%	2,818%	2,758%	2,798%	3,052%
Costs of providing assistance to suppliers	1,078%	1,227%	1,005%	1,246%	1,094%
Costs of working quality department	2,097%	2,438%	2,732%	2,023%	1,902%

	2010	2011	2012	2013	2014
Costs of buying and maintaining external documentation	1,462%	1,498%	1,147%	1,238%	1,348%
Costs of management of internal documentation and records	10,639%	10,011%	8,717%	7,585%	8,996%
Costs of preventive action	12,622%	12,037%	11,376%	9,936%	12,400%
Costs of remedial measures	2,306%	2,270%	2,121%	2,512%	2,169%
Costs focused on continuous improvement	9,375%	9,028%	7,438%	9,466%	9,506%
Training costs, employee education and development costs	3,377%	4,055%	3,286%	3,790%	2,814%
Costs focused on impelementation of incentive programs	47,275%	48,105%	52,899%	52,535%	49,777%
Costs of membership in professional organizations and societies	9,501%	9,120%	9,078%	9,440%	9,775%
Costs for management review of quality by leadership	0,268%	0,211%	0,201%	0,230%	0,217%

Source: Author

Tab. 4: Costs of prevention

	2010	2011	2012	2013	2014
Costs of processes of control	40,259%	40,474%	40,603%	40,839%	40,766%
Costs for review of documentation	1,643%	1,652%	1,657%	1,667%	1,664%
Costs of operation tests	6,845%	6,882%	6,904%	6,944%	6,931%
Costs of buying services from external laboratories	0,121%	0,106%	0,096%	0,086%	0,102%
Costs of product conformation	0,102%	0,117%	0,103%	0,088%	0,081%
Costs associated with the obtaining Czech conformity mark	0,094%	0,079%	0,072%	0,070%	0,078%
Costs for purchase of measuring equipment	5,093%	4,627%	4,842%	4,216%	4,542%
Costs of calibration	2,464%	2,477%	2,485%	2,500%	2,495%

	2010	2011	2012	2013	2014
Maintenance costs	12,093%	12,158%	12,197%	12,268%	12,246%
Costs for development and production of special equipment	24,643%	24,775%	24,854%	24,998%	24,953%
Costs of marketing tests	3,190%	3,198%	2,739%	2,862%	2,697%
Costs of production samples	2,464%	2,477%	2,485%	2,500%	2,495%
Costs of continuous processes of inventory control	0,010%	0,010%	0,009%	0,010%	0,009%
Costs of creating self test conditions at the workplace	0,095%	0,091%	0,086%	0,084%	0,080%
Audit costs	0,874%	0,870%	0,862%	0,861%	0,853%
Costs of assessing capacity of machines and processes	0,009%	0,008%	0,007%	0,007%	0,008%

Source: Author

Tab. 5: Total costs of quality

	2010	2011	2012	2013	2014
Costs of prevention	4,077%	3,763%	3,870%	3,917%	3,611%
Costs of appraisal	44,419%	41,371%	42,715%	43,757%	44,626%
Costs of failure	51,505 %	54,866 %	53,415 %	52,326 %	51,763 %

Source: Author

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Received: 04. 02. 2017, reviewed: 15. 08. 2017, 11. 05. 2017
Approved for publication: 23. 10. 2017