ECONOMIC INDICATORS OF QUALITY AND THEIR INFLUENCE ON COST EFFECTIVENESS

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ABSTRACT

Purpose: Economic optimum of quality is to find a balance between quality and costs of quality, therefore it is very important to monitor quality costs and economical indicators for valuation of cost effectiveness. All economic indicators can provide information to the company in terms of quality costs trend. All indicators are important for to improve TQM performance and for continual improvement of quality. The relative importance of economic indicators brings knowledges for managers to value cost effectiveness.

Methodology/Approach: In this paper we use economical and statistical indicators for quality costs. We use in this paper model PAF, that it include prevention costs, evaluation costs, internal errors costs, external errors costs. We used these statistical indicators: Total costs, Individual simple cost index, cost ratio and cost structure.

Findings: All these economic indicators can provide information to the company in terms of quality costs trend and their constant monitoring and management. Quality costs in relation to the profit participate with low percentage ie. the costs relative to quality significantly affect the generation of profits as their share of unit sales is too low, which is the most positive indicator of profit. While an index of costs in the monitored period decreases, which is in terms of this indicator positive phenomenon and it is not necessary to optimize the costs of the quality in relation to the reported sales.

Originality/Value of paper: Cost effectiveness helps to improve TQM performance. TQM is a major business strategy for the company. Cost of quality influence to profit in the industrial company and profit is very important indicator for next business activities.

Keywords: costs; quality costs; profit; statistical indicators; PAF model
1 INTRODUCTION

Economics of quality is an area that plays an important role in the system of quality management and evaluation of quality costs. (Ozkan, et al., 2013) Quality costs pursuing activities related to quality such as prevention, evaluation, quality measurement and detection of poor quality. (Čierna, 2006) Economic optimum of quality is to find a balance between quality and costs of quality and it is therefore necessary to monitor quality costs and their synergistic effect in relation to the level achieved by the economic efficiency of the company. (Rodin, et al., 2012) The overall approach to assessing the economic and statistical indicators required to register and monitor quality costs based on the classification of quality costs, the most commonly used classification model is PAF, which, however, has certain disadvantages both in terms of categorization of quality costs only into three cost groups. A critical factor of such system of organization is the evaluation of the risk in quality of production. (Turisová et al, 2012) Evaluation of the quality costs, and use of statistical quality indicators allows us to monitor the dynamics of quality costs, the percentage of the total business costs. Performance measurement is a fundamental principle of management and it consists of quality indicators. (Kádárová et al., 2013) System of quality management is one of key indicators of business in industry in Slovakia. In this paper we analyze the economic-statistical quality indicators using a breakdown of the costs of quality according to the PAF model. Implementation of quality cost control is very important instrument for improving in area of quality management and quality cost control works as a latent management subsystem. This system creates framework for measuring and evaluating quality costs (Šatanová, et al., 2014).

2 MODEL PREVENTION APPRAISAL FAILURE – MODEL PAF

Monitoring of the quality costs can be made on the basis of different approaches, but for the evaluation of economic and statistical indicators of quality provides model PAF the best classification. Model PAF was created by the American company General Electric and is part of the British standard BS 6143, which divides the costs of quality to the category of the costs of prevention, assessment costs, costs of disagreements resp. errors (Hrubec, et al, 2009). These costs groups include:

Prevention costs – (efforts to avoid disagreement) the costs of any activity relating to the investigation, prevention, or reducing the risk of error, as well as the costs of quality improvement based corrections. This includes also the costs of various quality analysis, planning, information systems, upbringing, motivation and education, etc.
**Evaluation costs** – (assessment of the quality status) the costs for valuation whether the defined quality requirements have been reached. This includes all costs for measuring, checking, testing and verification of products and processes.

**Internal errors costs** – (internal failure) the costs incurred within the company due to handling of errors in fulfilling quality requirements of the customer. Include all costs of removal of disagreements with the documentation, on overtime for repairing, re-inspections and so on.

**External errors costs** – (external failure) the costs arising outside the company after delivery to the customer (user), arising from failure to meet user requirements on quality. They arise during use of the product as a result of poor quality of supplier’s work.

### 3 RESEARCH METHODOLOGY

For evaluation of economic and statistical indicators we will use exactly this approach in the assessment of quality costs, because the following indicators are based precisely on the model of the PAF.

To determine the total costs relating to the quality at the producer ($N_{QV}$) we base on the breakdown of costs according to the PAF model as follows (Čierna, 2006):

$$N_{QV} = N_I + N_E + N_H + N_P$$  \hspace{1cm} (1)

where:

- $N_I$ – total cost of internal errors for the period,
- $N_E$ – total cost of external errors for the period,
- $N_H$ – total cost of evaluation for the period,
- $N_P$ – total cost of prevention for the period.

The second statistical indicator which reflects the development of costs the observed period we refer to as:

**Individual simple cost index related to the quality at manufacturer ($I_{NQ}$)** is used to monitor the dynamics of quality costs in two consecutive periods and expressed as follows:

$$I_{NQ} = \frac{N_{NQ1}}{N_{NQ0}}$$  \hspace{1cm} (2)

$N_{NQ1}$ – the total amount of costs related to the quality at manufacturer in the current period (1)

$N_{NQ0}$ – the total amount of costs related to the quality in the base period (0), immediately preceding period.
In assessing the economic efficiency of the company plays an important role the overall corporate costs, resulting from the exploitation of production factors, which take a part in making the profit. Indicator which expresses the relationship between the costs of quality and total costs is specified as the costs structure resp. portion of quality related costs to the total costs of the manufacturer – \( S_{NQ} \). Its use is effective if we want to regularly monitor the percentage of quality costs devolving to the processes of planning, regulating and improving quality in relation to total expenses.

\[
S_{NQ} = \frac{N_{OQ}}{N_c} \times 100 \% \tag{3}
\]

where: \( N_{OQ} \) – Quality costs in company,
\( N_c \) – total costs within the monitored period.

Based on the above we monitor the portion of quality costs in the monitored period to the total costs of the company i.e. operational, financial and extraordinary expenses.

Defines the percentage of the internal and external errors in the total costs related to quality in the company and thus highlights the extent of deficiencies in quality management.

\[
S_{nch} = \frac{N_{i} + N_{e}}{N_{OQ}} \times 100\% \tag{4}
\]

An important indicator for assessing economic efficiency in terms of quality is also an index of costs, which reflects how much money units of costs fall to one unit of income. This index can be expressed relative as a percentage.

Costs ratio is expressed by the following equation:

\[
n = \frac{N_{OQ}}{T} \times 100 \% \tag{5}
\]

where: \( N_{OQ} \) – quality costs in the company,
\( T \) – sales in the monitored period.

4 RESEARCH - ANALYSE OF QUALITY COSTS

Overall assessment of the economic-statistical indicators of quality we implemented in a company with legal form of a private limited company (Ltd.), capital amount of €35 million, with approximately 650 employees, whose
business is mainly manufacture metal castings, wood products manufacturing, service, rental, storage activity, metal finishing, etc.

Based on this classification of costs, we analyzed the quality costs in the company and the different types of quality costs we assigned to the PAF model as follows:

Table 1 – Classification of costs species according to the PAF model

<table>
<thead>
<tr>
<th>Prevention costs</th>
<th>Evaluation costs</th>
<th>Internal errors costs</th>
<th>External errors costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality management department trainings</td>
<td>Costs of the initial control</td>
<td>Costs of individual products wasters</td>
<td>Claims costs</td>
</tr>
<tr>
<td>Workers-welders trainings</td>
<td>Costs of production control</td>
<td>Mechanical machining errors</td>
<td>Fines costs</td>
</tr>
<tr>
<td>Costs of documentation</td>
<td>Costs of metrology</td>
<td>Material forming errors</td>
<td>Costs of penalties</td>
</tr>
<tr>
<td>Costs to assess supplier</td>
<td>Costs of calibration</td>
<td>Material errors</td>
<td>Costs associated with the loss of key customer</td>
</tr>
<tr>
<td>Audits costs</td>
<td>Costs of defectoscopy</td>
<td>Welding errors</td>
<td>Costs of stopping production</td>
</tr>
<tr>
<td></td>
<td>Costs of test tools and their maintenance</td>
<td>Finishes/Surface treatment errors</td>
<td>Costs of loss caused by production delays</td>
</tr>
</tbody>
</table>

Based on the classification according to table 1 we summarized the quality costs into four categories according to the PAF model.

Table 2 – Costs of quality in company according to the PAF model.

<table>
<thead>
<tr>
<th>Model PAF/Costs (in €)</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevention costs</td>
<td>19,085</td>
<td>14,278</td>
<td>13,829</td>
</tr>
<tr>
<td>Evaluation costs</td>
<td>117,100</td>
<td>116,790</td>
<td>116,480</td>
</tr>
<tr>
<td>Internal errors costs</td>
<td>9,402</td>
<td>7,432</td>
<td>1,450</td>
</tr>
<tr>
<td>External errors costs</td>
<td>61,711</td>
<td>31,478</td>
<td>24,186</td>
</tr>
</tbody>
</table>

In the classification of quality costs we can conclude that the highest value – the costs of assessment is related to the production process and the company activities that are necessary for the quality control of products such as: measurement, calibration, input and output monitoring, sampling, etc.. The value of the costs in company is high and cannot be significantly reduced, because otherwise it could be expected that there will be a decrease in product quality and increase of the costs of mistakes. Detailed examination of these groups of quality costs we implemented through economic-statistical indicators.
5 ANALYSIS OF ECONOMIC AND STATISTICAL INDICATORS

For evaluation of economic and statistical indicators we will use exactly this approach in the assessment of quality costs, because the following indicators are based precisely on the model of the PAF.

To determine the total costs relating to the quality at the producer \( N_{QV} \) we base on the breakdown of costs according to the PAF model as follows (Čierna, 2006):

\[
N_{QV} = N_I + N_E + N_H + N_P
\]  

(1)

where:

- \( N_I \) – total cost of internal errors for the period,
- \( N_E \) – total cost of external errors for the period,
- \( N_H \) – total cost of evaluation for the period,
- \( N_P \) – total cost of prevention for the period.

Table 3 – Total costs of quality at manufacturer.

<table>
<thead>
<tr>
<th>Model PAF/Costs ( in €)</th>
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<th>2013</th>
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<tr>
<td>External errors costs</td>
<td>61,711</td>
<td>31,478</td>
<td>24,186</td>
</tr>
<tr>
<td>( N_{QV} )</td>
<td>207,298</td>
<td>169,978</td>
<td>155,945</td>
</tr>
</tbody>
</table>

Based on the reference indicator of the total costs of quality in the company we can conclude their drop since 2011 by €51,353. Reducing the costs of quality is reflected in particular in reducing the costs of internal and external quality defects and savings was also recorded in quality prevention costs of €5,256. The PAF model recommends costs reductions in the errors costs group. Costs of prevention in regard of continuous quality improvement may not reduce, but rather may record an increase, because prevention is considered to be an instrument of the prevention of errors and deficiencies, non-conformities in quality.

The second statistical indicator which reflects the development of costs the observed period we refer to as:

**Individual simple cost index related to the quality at manufacturer** (\( I_{NQ} \)) is used to monitor the dynamics of quality costs in two consecutive periods and expressed as follows:
Considerable change in the costs of quality was recorded in 2012, where there was a total change in the quality costs by 18% compared to 2011. In 2013 compared to 2012 occurred 8% change in the costs of quality. Significant changes are most apparent in costs of internal errors, no change was noted in evaluation costs, where the amount of costs fell down, but not significantly because the company is monitoring in this group of costs also the costs on metrology, calibration and defectoscopy that is spent in each reporting period.

In assessing the economic efficiency of the company plays an important role the overall corporate costs, resulting from the exploitation of production factors, which take a part in making the profit. Indicator which expresses the relationship between the costs of quality and total costs is specified as the costs structure resp. portion of quality related costs to the total costs of the manufacturer – ($S_{NQ}$). Its use is effective if we want to regularly monitor the percentage of quality costs devolving to the processes of planning, regulating and improving quality in relation to total expenses.

$$S_{NQ} = \frac{N_{QV}}{N_c} * 100\% \quad (3)$$

where: $N_{QV}$ – Quality costs in company,

$N_c$ – total costs within the monitored period.
Based on the above we monitor the portion of quality costs in the monitored period to the total costs of the company i.e. operational, financial and extraordinary expenses.

Table 5 – Quality costs structure

<table>
<thead>
<tr>
<th>Model PAF/Costs (in €)</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOV</td>
<td>207,298</td>
<td>169,978</td>
<td>155,945</td>
</tr>
<tr>
<td>Nc</td>
<td>119,262,925</td>
<td>125,621,734</td>
<td>128,758,635</td>
</tr>
<tr>
<td>SQ</td>
<td>0.17 %</td>
<td>0.13 %</td>
<td>0.12 %</td>
</tr>
</tbody>
</table>

The costs structure is an important indicator in terms of company costs optimization and an instrument resp. a mean for exploring the possibilities of reducing the unproductive cost items. On the basis of the analysis we can conclude that the portion of quality costs in relation to the total company costs is low and level of these costs does not significantly affect the company's formation of profit resp. business efficiency. Also based on defined structure, we can conclude that the portion of quality costs since 2011 has gradually decreased.

Decrease in the costs of quality has also reflected in the change of the quality costs structure, based on the PAF model in the chosen company, where the amount of total business costs since 2011 has risen slightly, while also increasing sales volume. Due to the increase in the total costs we should expect a slight increase in the costs of quality, but the trend was reversed, quality costs decreased slightly, which was reflected in the removal of defects on the products.

If we step to the evaluation of the quality costs structure of each type according to the PAF model, we would find the following conclusions:

- structure of costs for prevention decreased by 0.34% compared to 2011
- structure of costs for evaluation showed an increase of 18.2% over 2011
- structure of costs for internal errors fell by 3.61% compared to 2011
- structure of costs for external errors fell by 14.26%.

The total change in the structure of quality costs in the company changed on the basis of the development of individual types of costs broken down by the PAF model. Despite the fact that significant structural change occurred in costs for evaluation, numerical expression of costs has changed only by the amount of €620. Change in the structure for this item increased significantly, but only due to the fact that there was a decrease in the total value of the cost of quality in the company, which was reflected right in the costs of evaluation.
Based on Fig. 1 we can conclude that the costs savings recorded in the costs of prevention, internal and external errors greatly affect the costs for quality in the company. Thanks to the decrease of costs that were spent on errors, not only the financial savings were achieved but also an improvement in product quality, which was reflected in lower levels of customer complaints.

If we take a closer look at the portion of the costs of internal and external errors to the total costs it can be expressed as:

**Portion of the costs for errors to the total costs related to quality at manufacturer – \((P_v)\).**

Defines the percentage of the internal and external errors in the total costs related to quality in the company and thus highlights the extent of deficiencies in quality management.

\[
S_{nch} = \frac{N_i + N_e}{NQ_v} * 100\% \tag{4}
\]
Table 6 – The errors costs structure

<table>
<thead>
<tr>
<th>Model PAF/Costs (in €)</th>
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<th>2012</th>
<th>2013</th>
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<tr>
<td>External errors costs</td>
<td>61,711</td>
<td>31,478</td>
<td>24,186</td>
</tr>
<tr>
<td>Errors costs</td>
<td>71,113</td>
<td>38,910</td>
<td>25,636</td>
</tr>
<tr>
<td>NQv</td>
<td>207,298</td>
<td>169,978</td>
<td>155,945</td>
</tr>
<tr>
<td>Snch</td>
<td>34.3%</td>
<td>22.9%</td>
<td>16.5%</td>
</tr>
</tbody>
</table>

Portion of the costs for internal and external errors ranged from 16.5% - 35%, which represents the portion of poor production quality of the company and information for the management to address the issue of quality.

An important indicator for assessing economic efficiency in terms of quality is also an index of costs, which reflects how much money units of costs fall to one unit of income. This index can be expressed relative as a percentage.

Costs ratio is expressed by the following equation:

\[ n = \frac{N_{QV}}{T} \times 100 \% \]  

where: \( N_{QV} \) – quality costs in the company,
\( T \) – sales the monitored period.

Table 7 – Costs index

<table>
<thead>
<tr>
<th>Model PAF/Costs (in €)</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>NQv</td>
<td>207,298</td>
<td>169,978</td>
<td>155,945</td>
</tr>
<tr>
<td>Sales</td>
<td>119,362,506</td>
<td>125,721,315</td>
<td>128,858,216</td>
</tr>
<tr>
<td>n</td>
<td>0.17%</td>
<td>0.13%</td>
<td>0.12%</td>
</tr>
</tbody>
</table>

Quality costs in relation to the profit participate with low percentage i.e. the costs relative to quality significantly affect the generation of profits as their share of unit sales is too low, which is the most positive indicator of profit. While an index of costs in the monitored period decreases, which is in terms of this indicator positive phenomenon and it is not necessary to optimize the costs of the quality in relation to the reported sales.
6 CONCLUSION

In the evaluation of quality costs also other methods can be used in practice, that directly detect relationships between the cost of quality and total costs etc. These methods include for example: regression and correlation analysis, time series analysis, analysis of deviations, Pareto analysis, but also statistical testing through Grubs test, F test etc. (Plura, 2004) For evaluation of the costs of external errors related to monitoring of customer satisfaction is used in practice method EPSI. In terms of achieving high level of economic efficiency, it is necessary to determine level of costs of quality, which can ultimately positively or negatively influence the profit. If the acquisition costs of quality compared to total company costs would be too high, it can affect not only the amount of profit but also the marketing site relating to the quality of products or services company realizes while it can also manifest in customer complaints, due to poor quality, which is reflected in the costs of external product errors. In conclusion therefore we can state that the balance between production quality and cost of quality is an indicator that expresses mutual synergy and ultimately this would occur even at the cost of quality, which in the context of business costs should not exceed 10%. In the analyzed company, we have seen that the amount of the cost of quality is not negligible and in economic and financial terms is an item that the company has to spend to ensure the quality of their products, processes and services. Based on the objective analysis the company can control and influence the level of costs on quality and eliminate their share in the total costs, as we have seen in case of the costs of errors. All these economic indicators can provide information to the company in terms of quality costs trend and their constant monitoring and management.

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