APPLYING THE QUALITY MANAGEMENT SYSTEM AND OPTIMIZING ITS COSTS

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Abstract

The approach of this paper is to optimize the costs of applying the integrated quality management systems in industrial organizations. In this case, the optimization implies the determination of the limit of the costs generated by the quality system to which a maximum benefit is obtained or, in other words, the minimum cost to which the company's activities may materialize in the expected results through the implementation of the quality management system. The cost optimization for quality can be achieved in a complex way that is less used in the practice of organizations by mathematical modeling, or by an easier way – the preferred method by the practitioners – by comparing the performance of the organization with a reference standard (e.g. ISO 9001), which captures the difference from performance prior to the implementation of the quality management system. To justify the application of the second way (through comparisons), we propose to present the results of the study conducted by several industrial enterprises in Romania that have implemented the integrated quality management system.

Keywords: *optimization, cost of quality, econometric model, quality system, standard*

1. Introduction

Currently, most industrial enterprises have integrated quality systems in which, along with ISO 9001, two or more ISO standards have been implemented. In this situation highlighting and optimizing costs for quality becomes more complex, less accurate and costly.

From the study we have undertaken in several industrial enterprises, it has emerged that the quality management system (TQM) based on ISO standards has made a definite improvement in the efficiency and competitiveness of enterprises. Improvement is, however, superior to companies that have implemented an integrated TQM system combined with the implementation of Kaizen continuous quality improvement methods.

As a result, we appreciate that in the future all organizations that will introduce a quality management system will assimilate the system proposed by us, namely the Integrated Management System for Continuous Quality Improvement (SIMICQ). The analysis of the efficiency of such a quality system can be achieved by mathematical modeling, but it is best suited to a methodology based on the evolution of the performance indicators, respectively, of our organization's financial indicators. Therefore, our study aims at developing a methodology for optimizing the quality costs of this model.

2. Optimizing the cost of the quality management system through econometric models

The implementation of the ISO quality system will generate costs on the one hand and benefits on the other hand. The decision of implementation is based on the criterion of economic efficiency, i.e. the impact that the implementation and operation of the system will have on the performance of the organization. This involves recording a minimum cost in order to obtain an expected benefit, or, in other words, getting the maximum benefit at a fixed cost, impact that we can determine with the help of appropriate econometric models. It follows that cost optimization in this case is a typical problem of mathematical analysis whose function, in relation to the objective pursued, may be maximum or minimum, as follows: either a function **F** for which there is a set of values **V** belonging to the string of real numbers **R** and ***X0*** is an element of the **R** string so that minimizing the cost for an expected result or maximizing the results at a fixed cost can be defined as:

(1) $F(X_0) \leq F(x)$ *for minimization*

(2) $F(X_0) \geq F(x)$ *for maximization*

The F (x) function is called the objective function or cost function. It follows that for the optimization of the costs of the quality management system we can use the cost - benefit model which according to relations (1) and (2) is given by the relation:

(3) $VNA = \sum_{n=1}^{D} \frac{B-C}{(1-r)^n}$

In which: [n = 1...D]; VNA = net updated value; B = estimated value results; C = costs;

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r = discount rate; n = reference year; and D = the horizon analyzed in years.

The goal is to maximize VNA, which is the same as determining the minimum costs. The quality generated by the ISO 9001: 2015 standard can be analyzed for a period longer than one year. Thus, to calculate the sum in equation (4) we will include these multiples of years, i.e. VNA_0, VNA_1, ..., VNA_D for n_0 to n_D. This series of VNA data allows testing to determine how well the resulting VNA value falls within the proposed limit (E). The best analysis can be done by the chi-square test whose calculation relation is:

(4) $X^2 = \sum(O - E)^2 / E$,

Where: O = the obtained value; E = the expected value for the VNA

In VNA_0, VNA_1, ..., VNA_D, there is the highest VNA value resulting when the VNA maximum was produced at the lowest cost, that is the optimal cost. We will use the resulting VNA value as a comparison with the proposed VNAE. If this value is within the VNA> VNAE, then the corresponding VNA cost is the optimal cost.

If the difference between VNA_1, VNA_2, ..., VNA_D is, for example, at 0.95 (Bradley, Hax, Magnanti, 1977) confidence interval for VNA values at time n_0, n_1, ..., n_D to the degree of freedom 4 (we considered the 5-year period to confirm cost minimization or cost optimization), the chi-square values of the variables analyzed should be equal to or greater than 9.50. The optimal cost is found at the point analyzed for which the difference value is greater than 9.50.

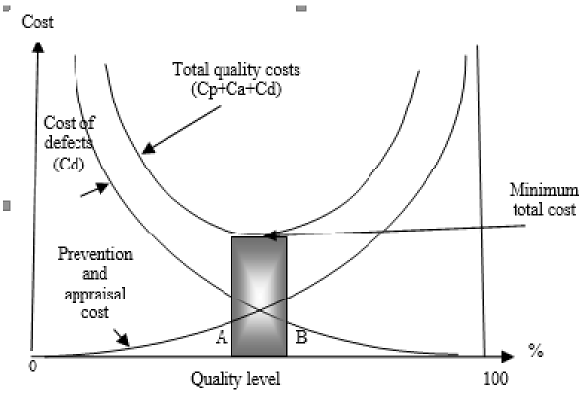
The specialty literature also presents other econometric models that can optimize the cost of the quality system. We mention the Juran model, the Schneidermann model and the improved ISO, Six Sigma econometric models.

2.1. The Juran Model

The basic premise of this model is that the evolution of quality costs in an enterprise is determined by two fundamental variables: prevention costs and failures costs. Each of these cost categories is represented by two curves, one decreasing – the cost of the failures (defects) and another increasing – the costs of prevention and appraisal from the chart in Figure no. 1, and their sum is even the total cost of quality that is sought to be minimized (Figure 1) (Ioniță, 2008).

According to this model, the cost-quality correlation highlights that as the new methods and techniques are implemented to prevent errors, the overall cost of quality is reduced as a result of lower costs due to the defect products. The efficiency with which resources are used in preventive purposes is maintained only up to an optimal point (in Figure 1, the shaded area between points A and B), where the minimum cost is obtained and the quality level is considered optimal. In this interval the costs of defects (Cd) are approximately equal to those of prevention and appraisal (Cp + Ca) of defective products. The efficiency with which preventive resources are used is maintained only at the optimum point where the minimum total cost is obtained. Beyond this optimal area (A and B), increasing the prevention costs leads to a further reduction in the cost of defects, but to a lesser extent compared to effort. Therefore, the total cost of quality increases faster than the quality level. As a result, it is preferable for economic agents to position themselves in the optimal area where there is a balance between the efforts to increase quality and the results that are obtained.

Fig. no. 1. Standard Model of Quality Costs presented by J. M. Juran in 1951

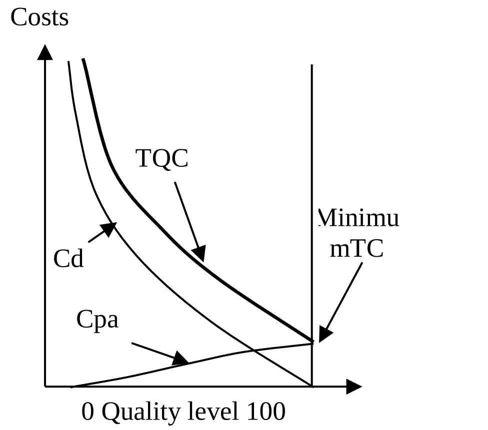


2.2. The Schneidermann Model

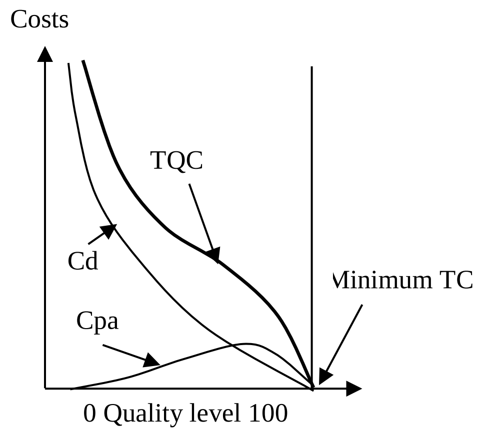
This model presents a modern approach to the correlation between cost and quality. The assumption from which it is based is the existence of a theoretical balance between the points corresponding to the minimum total cost, the prevention and appraisal cost and the cost of the failures.

According to the point where the total cost is minimal, a maximum level of quality (quality equivalent to the "zero defects" principle) is achieved, because the implementation of the continuous improvement strategy promoted by the Kaizen management model does not require infinite investment. Because short-term prevention and evaluation costs are cumulative and evolve after the equation of an ascending parable (starting at a minimum), it is considered that these two cost categories may in the long run be zero, while improving the level of quality during the period of use of the good. Thus, in the long-term, it is possible to improve the quality of excellence with low resource consumption. Schneidermann's model therefore relies on the philosophy of excellence, founded in the 1980s, that the quality obtained should not be optimal but perfect in terms of efficiency, which implies minimal expenses, considering being inacceptable the cost-quality correlation promoted by Juran's classic model. In Figure no. 2 it is represented the approach of the cost-quality correlation in the Schneidermann model (Schonberger, 1988, cited by Olaru, 1999).

Fig. no. 2 Approach cost-quality correlation in Schneidermann's model



A



B

A. minimum total short-term cost (zero defects);

B. the effects of simplification (long-term) improvement;

Cpe - the cost of prevention and evaluation;

Cd - costs of defects;

Minimum CT - Minimum total cost of quality

Nowadays in the specialty literature, there are presented improved econometric models for optimizing the quality of costs, among which, more significant, we have seen the ISO model and the Six Sigma model.

3. The basis for the decision of implementing the integrated quality management systems by determining the competitiveness gained by the company

If the impact of total quality management system – TQM can be measured by comparing the organization's performance with a benchmark (e.g. ISO 9001) that captures the difference from performance prior to TQM implementation or by optimizing the cost of quality using econometric models that we have presented, in the case of the quality system proposed by us the efficiency / performance will be measured by a methodology based on the analysis of the performance indicators of the organization. This orientation is based on the findings of the companies where we have been documented to prepare this paper, and where the decision to implement cost-optimized quality systems using econometric models is not approved by management.

The results of our research have highlighted several situations that justify the position of managers in this case, as follows:

- The actual reality in industrial enterprises shows that the quality system based on the ISO 9001 standard is outdated, with all industrial enterprises practicing for many years integrated quality systems so, alongside ISO 9001, they were implemented two or more quality standards. In this situation, highlighting and optimizing costs for quality becomes more complex, less accurate and costly;
- By the implementation of the quality system (TQM) based on ISO standards, there has been a definite improvement in the efficiency and competitiveness of enterprises. However, the improvement is clearly superior for companies that have applied the integrated TQM system using Kaizen continuous quality improvement methods;
- In the case of generalizing the integrated management system of continuous improvement of quality, highlighting costs and optimizing them is very complicated.

Since, as we believe, in the near future, all industrial enterprises will move to this new quality system, a methodology should be established to analyze the effectiveness of its implementation, a methodology best suited to the evolution of performance indicators, respectively financial indicators of the company.

4. The system of indicators of economic efficiency analysis of the integrated management system of continuous improvement of quality

The implementation of a quality management system has as its primary objective the performance of the organization. Generally, performance is associated with two key processes – performance management and measurement. Performance measurement appears as a performance management sub process, which focuses mainly on identifying, tracking and communicating performance results using performance indicators. To measure and analyze the performance of some activities, processes, and projects that are essential within the organization, it is recommended to use Key Performance Indicators (KPIs). These indicators are basic elements of the performance measurement and monitoring process that quantifies the achievements of some activities, giving visibility to the performance of organizations. More specifically, once objectives have been set to implement the decision that will lead to increased performance our case – implementation of the chosen quality system, indicators are needed to measure the expected progress. It is this requirement that responds to the KPI, which will show the degree of achievement of the objectives. As a rule, a KPI-type indicator is expressed as a percentage or average, and it should respond in particular to the question, "Why?". Not everything that can be measured is a performance indicator. Thus, the fact that there were found, for example, 20 scrapes is not a KPI, but that there were 25% more scrap and two orders lost due to lack of customer confidence is a KPI.

Therefore, key performance indicators are quantitative measures, both financial and non-financial, on the performance of those tasks, operations or processes within the organization. The most used performance indicators are the financial ones, but the main indicators followed vary according to the industry (production, trade, professional services, etc.) and the function of the company (production, sales, human resources, financial etc.) by destination, could be the following: *strategic*, *managerial* or *operational*.

Strategic indicators provide information to a company's management about: return on invested capital, risk or opportunity, profit on assets used, turnover, market share, share price, employee satisfaction and customer satisfaction.

Managerial indicators provide management information such as availability of resources, effort level, and cost per unit of income.

Operational indicators provide information on individual performance – related to processes, activities, products, specifications, procedures, efficiency.

Although the enterprise's economic and financial performance measurement indicators are considered to refer to past performance, they have very useful information in economic analysis. Thus, the economic efficiency, determined with the help of the financial performance indicators, expresses, in the context of the insider's attributes, precisely the result of the implementation of the quality system, materialized in the continuous improvement of the products, processes, activities and proper involvement of the motivated employees the degree of achievement of the set goals and the satisfaction of a number of customers in line with the company's capabilities and environmental objectives.

For a helpful, meaningful analysis of the objectives we have been pursuing in the case study that we have presented, we have carefully selected the key performance indicators by choosing those who provide the competitive advantages generated by the quality system, are directly related to performance, measurable and provide comparability to various references. In order to highlight the contribution of the implementation and operation of the integrated quality management system to the improvement of the economic and financial results of the analyzed enterprise, we have used the following indicators: turnover (CA), variable costs, variable costs margin (MCV), fixed costs, operational profit, profitability threshold (PR), investment recovery term (T), economic rate of return on investment (RRE), updated net income (VNA), and economic efficiency (R).

5. Applying the proposed method to evaluate the efficiency of quality management system in an industrial company

The company which we will exemplify the proposed method manufactures high-tech electronics and home appliances, used for household needs. It has 2,500 employees and a turnover of 384 million Euros in 2015. The company has implemented an integrated quality management system – ISO 9001: 2008, ISO 14001: 2005, ISO 50001: 2011, implemented in two stages. In 2007 it was implemented the integrated system ISO 9001: 2008 and ISO 14001: 2005, and since January 2014 it was also implemented the ISO 50001: 2011 standard, being a high-energy consumer enterprise.

Together with this integrated quality system, the company has implemented, since 2014, the Kaizen continuous improvement quality management system. Thus, "*6 sigma methods*", "*total productive maintenance*", "*just in time*" have been integrated. As will be shown below, the implementation of the quality management system has had a strong impact on the efficiency of the company.

We have made this case study to demonstrate the efficiency of the implementation and operation of the integrated management system for the continuous improvement of quality in industrial organizations. Thus, we have first analyzed the impact of the implementation of the integrated quality system, comprised of the three previously mentioned standards, for the period 2006-2011 and then the one generated by the combined action of the integrated system and the integrated system of continuous improvement of quality for the period 2011-2015, under the conditions of application of the Kaizen methods.

5.1. Analysis of the efficiency of implementing the integrated quality system in the company during the period 2006-2015

Table 1: Excerpt with the company's financial data before the implementation of the quality management system (Year 2006)

Economic indicator	Value (thousand Euros)	Percentage of turnover, %
Turnover	190,000	100.00
Variable costs	114,750	60.39
Variable Cost Margin (MCV)	75,250	39.61
Fixed costs	66,500	35.00
Operational profit	7,030	3.70

With these values, the profitability threshold can be determined by the formula:

$$PR = \frac{CF}{MCV} \times 100$$

CV – Variable costs;

MCV – Variable Cost Margin;

PR – Profitability threshold;

CF – Fixed costs;

$PR = \frac{66{,}500}{75{,}250} \times 100 = 88.37\%$ of the production capacity

Thus, the profitability threshold expresses the minimum percentage of activity reported to the production capacity, for which the profit is null.

The results show that for the analyzed company the profitability threshold is 88.37% and in absolute values 167907 thousand Euros.

If the variable cost margin is used, determined as a percentage of the turnover, the profitability threshold value is reached, i.e. the minimum value of the turnover for which the profit is null. The calculation formula is:

$PR = \frac{CF}{MCV\%} = \frac{66{,}500}{39.61\%} = 167{,}887$ thousand Euros

In the same year, the total costs of non-quality, represented by the cost of internal and external defects, which amounted to 28,000 thousand Euros, equivalent to 14.74% of the turnover, were quantified. This means that, in fact, the actual variable costs were only 75,250 × (100 – 15) = 63,963 thousand Euros, and the difference, amounting to 11,287 thousand Euros, represents non-quality costs.

The successful **implementation of the quality management system** meant a considerable improvement of the economic indicators, which is noticeable by consulting the company's financial data for 2011 (Table 2).

Table 2: Excerpt with the company's financial data after the implementation of the quality management system (Year 2011)

Economic indicator	Value (thousand Euros)	Percentage of turnover, %
Turnover	253,000	100.00
Variable costs	153,000	60.47%
Variable Cost Margin (MCV)	100,000	39.53%
Fixed costs	90,330	35.70%
Operational profit	12,905	5.1%

As you can see, the value of the turnover reached 253 million Euros. Stabilization of the manufacturing process has led to a reduction in the cost of defects, which has resulted in an 84% increase in profit over 2006.

The results show that the profitability threshold is 90.3% in 2011 and in absolute values of 228,510 thousand Euros.

$PR = \frac{CF}{MCV\%} = \frac{90{,}330}{39.53\%} = 228{,}510$ thousand Euros

$PR = \frac{90{,}330}{100{,}000} \times 100 = 90.33\%$ of the production capacity

The fact that the profitability threshold is higher than in 2006 can be explained by the faster growth of turnover and investment.

Also for the year 2011 were quantified the total costs of non-quality, represented by the cost of internal and external defects, which amounted to 23,276 thousand Euros, equivalent to 9.2% of the turnover. This means that, in fact, actual variable costs were only

100,000 × (100 – 9.2) = 90,800 thousand Euros, and the difference of 9,200 thousand euro represents non-quality costs.

The successful **implementation of the integrated quality management system and the integrated quality continuous improvement system** meant practically an approach to reaching the zero defective target, as can be seen from table no. 3, with the company's financial data for 2015.

Table 3: Excerpt with the company's financial data after the implementation of the integrated quality management system and the integrated quality continuous improvement system (Year 2011)

Economic indicator	Value (thousand Euros)	Percentage of turnover, %
Turnover	384.000	100.00
Variable costs	230.400	60.00
Variable Cost Margin (MCV)	153.600	40.00
Fixed costs	134.400	35.00
Operational profit	19.200	5.00

As shown in Table 3, the turnover reached 384,000 thousand Euros, representing an increase of 152%. Stabilization of the manufacturing process led to a reduction in the cost of defects, which resulted in an increase in profit of 1.5 times compared to 2011. This means that a 9.2% reduction in defective costs has led to an increase of about 50% profit.

The results show that for the analyzed company the profitability threshold is 87.5%, and in absolute values of 336.000 thousand euro.

$PR = \frac{CF}{MCV\%} = \frac{134{,}400}{40.00\%} = 336{,}000$ thousand Euros

$PR = \frac{134{,}400}{153{,}600} \times 100 = 87.50\%$ of the production capacity

Also for the year 2015 were quantified the total costs of non-quality, represented by the cost of internal and external defects, which amounted to 7,680 thousand Euros, (that is, three times lower than in 2011) equivalent to 2.0% of the turnover. This means that, in fact, actual variable costs were only 153,600 × (100 – 2.0) = 150,528 thousand Euros, and the difference of 3,072 thousand Euros represents non-quality costs.

This result shows that by successfully introducing of the integrated quality management system combined with management systems of continuous improvement of quality – Kaizen it was reached the situation very close to zero defects objective (in this appreciation of the result, it must be considered that the integrated management system for continuous quality improvement was only present in three years of the five-year period considered). As a result, we appreciate that in the future all industrial enterprises will move to a quality system of the type that we have presented in this case study. The analysis of the efficiency of such a quality system is best suited to a methodology based on the evolution of performance indicators, respectively, in our case, the financial indicators of the enterprise.

6. Conclusions

It follows that by using the quality management system proposed by us, there is a significant increase in business efficiency and the business is much better protected in case of a potential demand reduction, due to the increased ability of the company to achieve profit. Also, in times of crisis, leadership can earn valuable time to get back on business. At the same time, the possibilities of increasing turnover are improved without any constraints in terms of production capacities or additional investments. However, the benefits obtained are complete only as long as the existing production capacities are fully utilized. This is also the objective of the management, the goal of the owners, but also the interest of the national economy.

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