CONSIDERATIONS ON QUALITY COST MANAGEMENT

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ABSTACT:
Quality costs alone do nothing to illustrate what is spent in various areas related to quality and showing opportunities for improvement. Using quality costs requires supporting the processing the costs for an analysis. One method is the presentation of quality costs as a percentage known to costs. This can show the value of quality costs in relation to expenses. Next, this data must be assembled and examined over time. The analysis may be carried out long-term and short-term. Learning is inherently repetitive of work processes. Both the quantity and quality of the repetitional work influence in a good way the effects of the learning process. As we produce more products identical or similar, the experience and performance in achieving them will increase. The learning rate is higher if the quality of the product is higher.
The learning process through specific effects has an influence on all costs, both on procedural costs and the additional costs that were intentionally made and we do not have any negative or unwanted results. Apply effects of the learning process in quality cost model or the quality of the relative costs lead to the same result, namely that the optimal quantity in the model is the same as the experience gained from the model Lundvall - Juran. The effect of learning must lead to improving the quality and lower profit rate leads to the highest optimum quality.

KEYWORDS: *quality costs • prevention, appraisal, failure • conformance level • learning curve, experience curve • optimum level of the economic*

JEL CLASSICATION: *D29*

1. INTRODUCTION

The concept **Cost of Quality** was initiated in the 1940s, when Kennedy in his "The Gold Mine in Quality Control" - 1946 highlighted the potential that could exploit the relative cost of quality (Sadoval-Chavez & Benevides, 2006). In the early 1950s the concept emphasizes the meaning of the cost in order to achieve the conformation with specifications, cost framed by Juran (1951) (Juran & Godfrey 1999), to tangible or intangible, depending on the possibility to quantify it. In 1954, Lesser, in his "Cost of Quality", suggests ranking of costs in **preventive, appraisal and failures**. Also, Feigenbaum in his book "Total Quality Control Handbook" model **PAF - preventive, appraisal, failure** reminds and develops the theory, according to which the costs of prevention and appraisal are opposite to the failures.

2. LUNDVALL-JURAN MODEL

-- indicates three areas, outlined in Figure 1, as follows:
- the improving zone ($q<q^*$)
- the indifference zone ($q=q^*$)

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- the perfectionism zone (q>q*)
q – conformance (quality)
q* - optimum level of the economic
The effort to establish economic optimum of quality is also determined by using the Lundvall-Juran model. As a result it achieves the concession between the costs of prevention, appraisal and failures.

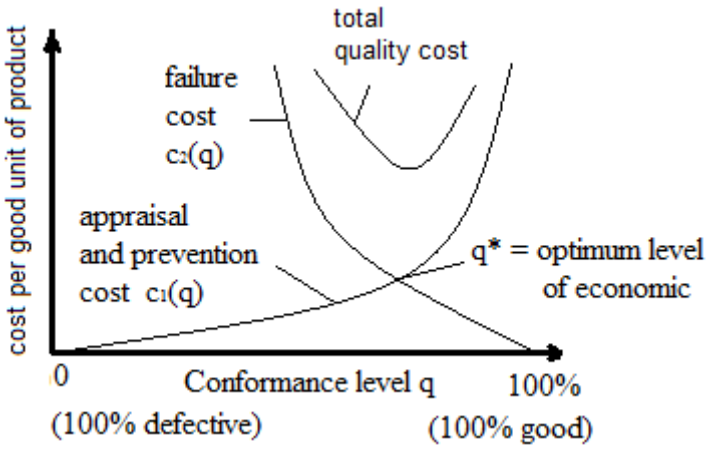

Fig. 1 Juran Model
Source: adapted from Dale & Hesford (1991)

The optimum level of the economic is achieved when $\mathbf{c_1(q)=c_2(q)=1/2\ c_{total}}$
According to Juran model diagram, investing in prevention-assessment costs, $c_1(q)$, at the point of minimum will lead in winning the investment by lowering the failure costs, $c_2(q)$. In the lower zone of the optimum level of the economic, q * investing in prevention, assessment costs, $c_1(q)$, saves more in reducing the failure costs defects, $c_2(q)$ and in the upper zone of the optimum level of the economic, q*, it happens exact the opposite. The cost, in theory, is understood as an "effort" on the expected income. According to the Lundval-Juran model, only $c_1(q)$ is a cost.
The cost is expressed through various efforts, and through this we want to obtain earnings represented by the quality of the products: sale, further requests, spending cuts. Above the economic optimum of compliance the unit cost exceeds the benefit obtained. This pattern is not appreciated because it indicates an optimum with a high proportion of defective products. According to Crosby's theory (1979) and Deming (1980), a high quality product is cheaper than one with low quality. In reality there are high quality products that have a higher cost in the beginning, but can achieve a low cost position later due to learning effects faster when producing higher quality levels.
Lundvall-Juran model admits for a moment that the level of conformance (q) is 100%, and the costs of prevention, appraisal $c_1(q)$ increase infinitely. Therefore, the additional cost of prevention, assessment $c_1(q)$ is specified, and the gain is zero, which can not be rational. We should make infinite investments in order to obtain zero failures (Militaru & Ghete, 2002), (Militaru & Ghete, 2003).

3. ZERO-DEFECTS MODEL

In their works, "Business Management and Quality Cost" published by Kume in 1985 and "Applying Quality Control to a Service Business" published Schneiderman in 1986 in his newspaper in order to criticize the PAF model. Their theory is based on the importance of assessment costs and not on the prevention ones. Thus, in an economic concept of mass production, inspection costs were necessary and they represented a high level. The aim was to minimize the use of non-conforming products, something which strongly obstructed the prevention investments. In addition, the concession expressed by the PAF model, according to which the economic optimum is when the two groups of accounts are

each equal to 50% of the total cost, it was agreed by Carr in 1992 (Carr, 1992), which introduced in evidence the intangible costs associated with quality showing that the shape of the curves moves to another aspect of the intersection. So if the traditional model remains to express the quality, it can not be applied dynamically, only static for deliverable products. In addition it can not explain the economic aspects owed to the quality in various stages of development, as demonstrated by Edmons in 1990 (Edmons, 1991). Criticizing the PAF model led to a rectified chart in which the optimal point is at the compliance of 100%, as shown in Fig. 2.

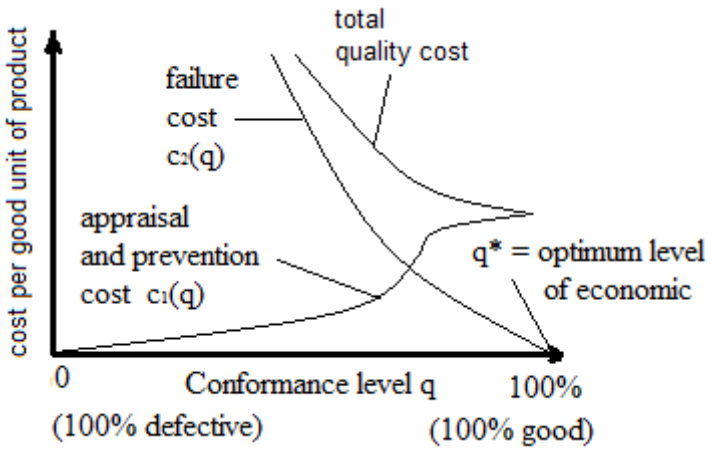

Fig. 2 Zero – Defects Model
Source: adapted from Parker(1998)

The optimum level of the economic is achieved when $\mathbf{c_2(q = 100\%) = 0}$
The minimum level of the economic is reached at q = 100% meaning zero defects, where the addition of prevention and appraisal costs $c_1(q)$ is less than the gain of failures, $c_2(q)$. Essentially the Zero Defects model supports incremental contribution to economic law according to which it is not economical to invested beyond the minimum total cost, but does not agree to stop investing in quality and deliver to the customer the defective product with a predefined rate, that is no longer economically justified to invest beyond this level of quality, q*, where per unit cost money we get less than one unit in income (Militaru & Ghete, 2003).
Studies performed within the automotive industry have shown that the number of direct labor hours in manufacturing automobile brake pads (Fig. 3), decreases with increasing the cumulative number of products made by an operator.

Fig. 3 Brake pads for automotive
Source: adapted from http://placutefrana.blogspot.ro/2010

Favorable consequences in individual productivity growth are due to profits obtained through learning content in achieving repeatedly the same operation or activity.
The model exemplified by the learning curve is explained in the diagram shown in Figure 4.

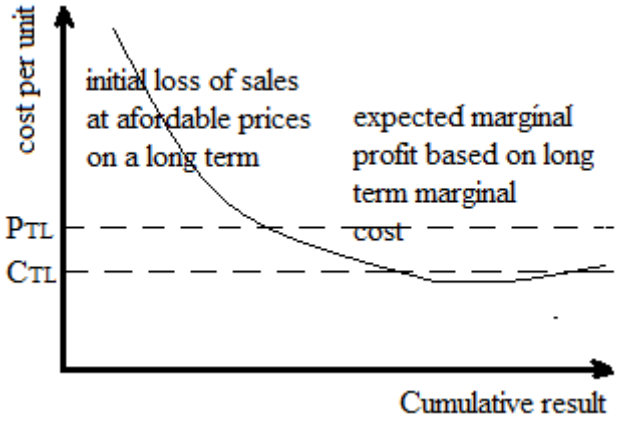

Fig. 4 Economies learning curve
Source: adapted from Winter & Bott (1997)

The learning curve is the rate that decreases the number of hours of work required for the production of brake pads as their current achievement. We can produce as soon as we learn more about our work and develop productive practices to that effect.
In the learning curve economies in Figure 4 we can observe how the marginal cost, which successively achieves the same type of brake pads for cars, drops, producing future income. The decrease is faster as we get even faster in the profits. In analyzes and decisions on profitability, must take into account the savings and the benefits produced by the effect of the learning curve.
Gains that can be obtained in carrying amounts for automobile brake pads are a reality and they are due to the effects of the process of experimentation conducted by an individual. The learning curve is similar to the experience curve. This curve expresses the same truth, that marginal intangible costs in achieving automobile brake pads, fall and through learning from the experience of similar manufacturing processes. The experience curve is represented a little different, as shown in Figure 5. This graphical representation form can easily distinguish the effects that can be achieved with a certain learning curve slope.

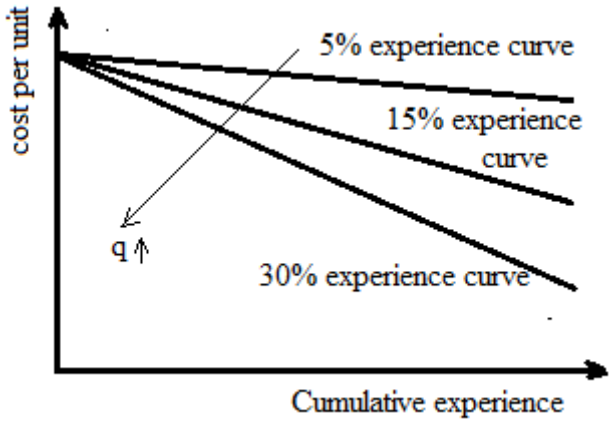

Fig. 5 Experience curve
Source: adapted from Winter & Bott (1997)

The 15% slope expresses an activity in which the firm learns to cut costs by 15% each time when successively accumulated results are doubled. The experience curve can be called the life cycle of the process, because what is considered a transfer is the way in which to process variables, specific only to the feature of the product. Experienced economies are achieved when the unitary price of

manufacturing a quantity of n+1 brake pads is smaller than the unitary price of manufacturing a number of n brake pads.

4. THE IMPORTANCE OF QUALITY ON TEACHING AND EXPERIENCE

In every field of activity, people learn how to reduce costs in various ways. Operators increase their speed or reduce speed of different used materials.it rethinks the flow so the required time and energy are reduced. If stocks are reduced then the specific costs will be reduced. Therefore, if a company learns how to become more efficient, profitable and also learns to reduce transaction costs, it can achieve economies of learning. The level of quality and the volume of production influence the learning rate. It makes the distinction between induced and autonomous learning. The induced learning results from the exercise, practicing and the autonomous learning involves little direct management operations. The quality-based learning includes both forms of learning.
The amount of production will increase the experience by autonomous learning due to the cumulative volume of products and the level of compliance (quality) is what will increase by induced learning. Production process becomes more efficient through the experience gained by making a copy of another product. Experience develops operator skill, this skill is required in increasing its productivity. Usually the quality is seen as expensive. It can be said that a high quality product costs. But reality has shown the opposite. Watching an high quality level in obtaining the brake pads, we will finally a final to achieve a low cost product. In other words, we will obtain free quality. If costs are affected by learning and experience curves, the rate of cost reduction is greater when experiencing high level of quality products from quality products with a lower level.
The decision on the quality of brake pads made for cars prejudices the learning rate and therefore reduces the rate of development costs. Companies that choose a higher quality standard to achieve brake pads learn faster than companies that made brake pads with lower quality standard. The high quality brake pads require a high level of control. The learning based on the idea that receiving quality products with highest quality standard causes increase learning speed.
It can be mathematically shown that optimizing the quality and the benefits of the learning curve are closely connected.
The mathematical demonstration requires the consideration of several hypotheses designed to remove overlapping effects primarily due to the scale effect, that large quantities - increased savings, and the conflicting ones with the position of the variation curves for binding and therefore costs. If you hide the effect of learning theory and experience the quality in full effect, the mathematical model wants to highlight the distinctive role of compliance in the rate of cost reduction and increased productivity. This means that in a period of time we sell a variable of brake pads at a price dependent on the installment sale. Income obtained is thus a function of the quantity sold and their associated prices. As the costs of achieving the brake pads decreases, according to the theory of learning and experience, we have a variable cost depending on the accumulated volume of brake pads made. If we want to maximize the profit we will need to solve in some cases, the equation with the following expression:

$$P(z)=\max [p(x) - c(z)] \quad (1)$$

where:

- **P(z)** – represents the maximum profit that can be obtained at a certain value of q;
- **q** – represents the level of compliance in Lundvall-Juran model;
- **p(x)** – represents the sale price that decreases with increasing of x (t), ie the amount of brake pads that we want to we sell at time t;
- **c(z)** – represents the unitary cost for achieving those brake pads, which decreases with increasing of acquiring experience;

In order to solve the above equation there were expressed three major assumptions that do not take into account the effect of multiple actions due to lower unit costs of producing high amounts of brake pads, the effect of changing demand by increasing compliance standards then the the effect of increasing q

compliance standards due to periodic repetition of a program or cut production.The model is studied in two situations. At first it is thought that the level of learning is exempted from all direct costs of manufacturing brake pads. In the second case it is considered that the effects of learning are exempt only to the prevention and conformity assessment costs. The learning gains are the result of level of quality and volume, we will apply them directly on manufacturing costs or on costs associated with conformance.

The effect of experience on the direct costs of the product. The total cost towards the realization of brake pads is the sum of the cost of manufacturing and the quality costs.

$$c(q,z) = c_1(q) + c_2(q) + c_3(z) \quad (2)$$

where:

$$c_1(q) + c_2(q) = c_{12}(q) \quad (3)$$

and the above relation becomes

$$c(q,z) = c_{12}(q) + c_3(z) \quad (4)$$

Profit optimization problem P(q,z) is:

$$P(q,z) = \max [p(x) - c_{12}(q) - c_3(z)] \quad (5)$$

where:

c_1 –unit costs of conformance;
c_2 – unit costs of non-conformance;
c_{12} – unit costs relative to quality;
c_3 – unit of production cost;
p(x) – sale price;
P(q,z) – represents the profit according to the conformance and experience.

The effect of experience on the direct costs of quality. This time we apply the the learning effect / experience on the direct costs of quality.

$$c(q,z) = a(z)\, c_1(q) + c_2(q) + c_3(z) \quad (6)$$

profit maximization requires:

$$P(q,z) = \max[p(x)-a(z)c_1(q)-c_2(q)-c_3(z)] \quad (7)$$

where:

a(z) – represents the effect of experience on conformance costs (a is decreasing and the limit tends to zero);

In both cases the curve on which the optimum quality ECL is moving is one that decreases over time and with increasing of the experience, the optimal point moves to the right and down as shown in Fig.6 (processed by Fine model results).

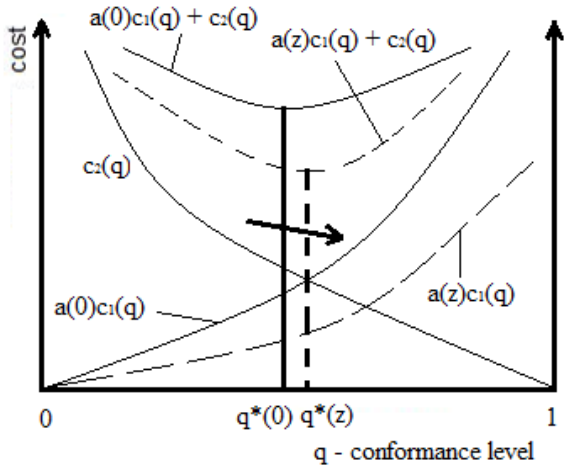

Fig. 6 Influence of the learning effects on relative quality costs
Source: made by Patrascan

The solid curve represents the costs without experience. The dotted curve represents the costs after a time t experience. Also **a(0) c_1 (q) + c_2(q)** the minimum in **q* = ECL**. For every z, **[a(z) c_1 (q) + c_2 (q)]** has a new q*(z)>q*(0).

5. QUALITY COSTS ANALYSIS

Quality costs alone do nothing than to illustrate what is spent in various areas related to quality and showing opportunities for improvement. Using quality costs requires supporting the processing the costs for an analysis. One method is the presentation of quality costs as a percentage known to costs. This can show the value of quality costs in relation to expenses. Next, this data must be assembled and examined over time. The analysis may be carried out long-term and short-term.
Long-term analysis - views the profile of the total cost and is useful for planning strategy and monitoring the general progress. The aim is high goals at the company.
Short-term analysis - is made for each area of the organization where they set individual goals for improvement. On short term we need to review the quality costs system to help us find the root causes and remove them. This time the targets are not general but very specific to an area of activity analyzed. It is important to understand that using the quality costs as a support to improve (before) and as way to verify the delivery of the proposed (after). Focusing on this will have a significant impact in raising the quality.

6. CONCLUSIONS

The learning process is inherently to repetitive work processes. Both the quantity and quality of the repetitional work influence in a good way the effects of the learning process. As we produce more products identical or similar, the experience and performance in achieving them will increase. The learning rate is higher if the quality of the product is higher.
The learning process through specific effects has an influence on all costs, both on procedural costs and the additional costs that were intentionally made and we do not have any negative or unwanted results. Apply effects of the learning process in quality cost model or the quality of the relative costs lead to the same result, namely that the optimal quantity in the model is the same as the experience gained from the model Lundvall - Juran. The effect of learning must lead to improving the quality and lower profit rate leads to the highest optimum quality.

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