On the Economics of Quality Improvement Activities

You-Dong, Won*
* College of Business & Commerce, Kyungnam University

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ABSTRACT

The concept of cost of quality has become important economic measures of quality issues for several decades. Most of the research to date has focused on the problem and solution under static business conditions. However, some researchers have found that prevention cost of COQ is one of the expenses of investment and the payback will be shown by the improvement of product quality. These approaches have considered cost of quality issues based on a time factor. It means that there is a trade-off between prevention/appraisal costs and failure costs. Based on a capital budgeting approach, this research reviews the economics of quality improvement activities and proposes the decision criteria to justify quality improvement activities.

1. Introduction

Since Juran(1951) first introduced the concept of cost of quality(COQ), COQ has been recognized as a critical measure of quality for several decades. A number of discipline have also been involved in this issue, such as system thinking approach, managerial accounting, economics as well as others. In the mean time, the practice of quality has been dramatically changed in last two decades, for example, such trends as ISO 9000 and TQM. However, most of the ISO 9000 and TQM activities have not consider their economic effectiveness until they become a financial burden to the firms. This paper investigates the economic effectiveness of quality improvement activities, by the incorporation of cost of quality philosophy and capital budgeting methodology.

2. Theory of COQ

2.1 Brief Review of COQ Theory

Quality of a product or service is important for the survival of a business, while cost of quality is one of the crucial measurements of quality from a management perspective. "Crosby views measurement of COQ as a necessity, but not for the purpose of having an exact figure. Rather, … it should capture management's attention and focus it on TQM"(Bowman, 1994). More specifically, some authors pointed out that quality and cost of quality are related to the critical issues of an individual company, such as market share(Field, 1999).

According to research in 1997, there are six primary theories related to the cost of quality, (1) Juran's Model, (2) Lesser's Classification, (3) Prevention - Appraisal - Failure Model, (4) The Economics of Quality, (5) Business Management and the COQ, and (6) Juran's Model Revised (Sandoval-Chavez and Beruvides, 1997).

In the past few decades, the cost of quality has been intensely studied in different academic disciplines. Many discussions related to managerial accounting focused on Activity-Based Costing(ABC) as well as the value added concept or the role of accounting professionals in quality improvement teams. Some economists attempted to take microeconomics theories, such as market competition model, to depict the behaviors of COQ variables. Operations researchers investigated the cost of quality from the inventory and optimization point of view. Others used a system theory approach. In addition to the traditional academic discussions, one of the most controversial issues is Taguchi's loss function. Since its success in engineering practice, some researchers have mentioned that the loss function might be one of the new ways to measure the hidden cost of COQ, because the hidden cost might be critical in this dynamic business environment.

2.2 New COQ Concepts in New Business Environment

The cost of quality concept emerged five decades ago under a relative simple business environment. However, this business environment has dramatically changed in the last five decades, it has been called the new economics(Deming, 1994). Many problems become apparent to COQ under the new economics. First, these changes may impact the theories of COQ, because some portions of COQ theories are changing under these new business conditions. Due to the changes, it may be necessary to redefine or modify some of the key elements of COQ theories, such as prevention, appraisal, and failure costs. Consequently, there may be new roles that the new COQ concept plays beyond the conventional quality measures and provides more assistance to the decision making process of management.

Under the new business environment, the concept of quality is more than just the quality of a product, or a service, it has been extended to the quality of systems. Therefore, quality issues no longer only deal with products or manufacturing process, COQ encompasses the whole system of a firm. Almost all the functions in a company are in the scope of the new quality management system (Noble, 2000 ; Weinstein, 1997).

Therefore, the cost of the total quality management will be a lot different from the original definitions of the cost of quality, which were based on the quality of a product or service, not a system. Questions will be raised under the new definition of COQ. What is the difference between the conventional COQ model and the new cost of quality system model? What are the real advantages of this new model to management? What is the difference or this new model to the traditional managerial accounting system? How can thus new concept be quantified? These are important questions to be addressed in the near future.

Besides the new scope of quality, Deming pointed out that zero defects is no longer the only requirement from customers; more elements must be considered for the survival of a business, such as style, comforts, functions, and innovation (Deming, 1994). There are other reasons for us to rethinking the definition of quality and the term cost of quality. It seems that something, beyond zero defects, has to be added to the definition of quality. For example, when discussing the issue of design for quality(DFQ), Morup(1992) found that total quality management has difficulties emerging from the lack of theoretical basis and limited insight to the features of design. In order to overcome the difficulties confronting DFQ, Morup suggests redefining the way to evaluate quality from different angles, such as value, incremental improvement to the customer, and quality.

Manay efforts on cost of quality has been made by the accounting discipline in the last few decades; however, there are some intrinsic problems when using traditional accounting techniques. Kaplan(1984) advised that the accounting and control system has big problems in the manufacturing environment, such as misallocation the product costs and not providing critical information for effective and efficient manufacturing purposes.

2.3 COQ in Total Quality Management System

The need for ISO 9000 quality management system was overwhelming in the international market of the 1990s. International purchasing orders required ISO 9000 certification from suppliers as a prerequisite. After the popularity of ISO 9000 quality management system, there were two other management systems published or proposed by the International

Organization for Standardization(ISO), namely ISO 14001 Environmental Management System, and the Occupation Safety and Health Management System. The international business community is beginning to integrate these three systems as a whole, the total quality management system.

What should a company do when dealing with the three systems together? Some authors are beginning to think about this question. Other questions will be raised in the mean time concerning the cost system regarding the new emerging total quality management system. Will the traditional P-A-F COQ model be enough to describe the cost behaviors under this new concept? What would it look like if these new items are integrated into the new cost of quality model?

Many people have mentioned the hidden costs when discussing COQ, but placed the discussions at a lower priority. However, almost every discussion recognized the importance of how hidden costs influence organizations. Sometimes hidden costs are also termed intangible cost, invisible loss, or opportunity cost. Due to the absence of the measurement of hidden costs or customer dissatisfaction in the research literature, Morse(1998) recommended the advantage of the Taguchi loss function. Actually, Albright and Roth(1992) have demonstrated how a mathematical relationship, known as the Taguchi quality loss function, can be used to estimate the cost of customer dissatisfaction and other hidden quality cost. The estimation of hidden costs by the Taguch quality loss function has later been questioned (Sandoval-Chavez and Beruvides, 1997). However, the approach of the Taguchi loss function for estimating hidden cost should not be totally reglected.

Juran attacked the bottom line of quality by stating, "The basic quality problem is to strike the correct balance between cost of quality and the value of quality for each quality characteristic"(Juran, 1951). This point of view is important for understanding the cost of quality, because the final goal of management is to generate value from product or service ; the cost of quality is a tool to reach that goal. However, very few studies have paid attention to this point.

In conclusion to this section, the systems approach of rethinking the definition of COQ in order to include the whole functions of a business is impacting to the theories of cost of quality. Based on the new system quality approach, the current theories of COQ might not be economically effective as decision tools for management. In this paper, an integrated model to depict the behaviors of the new total quality management system in order to help decision making for top management will be proposed.

3. Economics of Quality Improvement Activities

3.1 Analysis of Benefits Generated by Quality Improvement Activities

To consider an item of opportunity cost in this process, let's go back to the literature. Beruvides and Sandoval-Chavez (1997) developed a generic model to include opportunity losses into cost of quality:

$$C_T = C_P + C_A + C_F + C_0 \qquad (1)$$

where

C_T = total COQ expressed as revenue lost and profit not earned.

C_P = total expenses in prevention items.

C_A = total expenses in appraisal items.

C_F = total expenses in failure items.

C_0 = losses due to opportunity factors.

This research has simplified the prevention and appraisal costs as one term, prevention/appraisal costs. So the above model can be rewritten as follows:

$$C_T = C_{P\&A} + C_F + C_0 \qquad (2)$$

where

$C_{P\&A}$ = prevention and appraisal costs.

The basic definition for benefit(or profit, saving) is defined as follows:

$$B = R - C \qquad (3)$$

where

B = benefit(or profit, saving)

R = revenue

C = costs

Therefore, the specific benefit(or profit, saving) brought by an investment (prevention/appraisal activities) in period t can be stated as follows:

$$\varDelta B = B_t - B_{t-1} \qquad (4)$$

Using equation (3), equation (4) can be expressed as:

$$\varDelta B = B_t - B_{t-1}$$

$$= (R_t - C_t) - (R_{t-1} - C_{t-1}) \qquad (5)$$

$$= (R_t - R_{t-1}) + (-(C_t - C_{t-1})) \qquad (6)$$

The difference in costs, $-(C_t - C_{t-1})$ can be defined as saving from reduction in failure costs(i.e. S_t). We may define a term B_C to express the value of benefit obtained based on the reduction of costs.

Now let us consider that the difference (i.e. increase) in revenue that may come from the saving(or benefit) by avoiding opportunity loss, B_0, due to the quality improvement or the reduction of product or system failures. According to the research conducted by Beruvides and Sandoval-Chavez(1997), opportunity loss is responsible for 83% of total revenue loss. In other words, the saving(benefit, or profit) from preventing opportunity loss can be many times that of savings from the reduction of failure costs. Thus, we can rewrite equation (6) as follows:

$$B_T = B_0 + B_C \tag{7}$$

where

B_T = the total benefit(or profit, saving) brought by an investment (prevention/appraisal activities) in a specific period(= ΔB)

B_0 = benefit or profit generated by avoiding opportunity loss

B_C = benefit or profit generated by the reduction in failure cost

3.2 Decision Criteria for Quality Improvement Activities

In order to justify the economic effectiveness of quality improvement activities, the capital budgeting methodology should be employed to make decision. Canada, Sullivan and White(1996) depicted the methodology as follows: "We define an opportunity as being worthwhile if it has either a nonnegative present value, … a rate of return at least equal to the minimum attractive rate of return (MARR)."

Among these measures on economic effectiveness, the present value method and rate of return method are the two more representative approaches. In this paper, the rate of return method is employed to demonstrate the economic issue concerning cost of quality. About the rate of return, the authors stated that, " … the most popular definition is the interest rate that yield a net present value of zero : such a rate of return is referred to as the internal rate of return(IRR)".

Using the above stated concept, the following equation in net present value form on the investment of quality improvement activities is proposed.

$$NPV = (B_C + B_0)(P/A, i\%, n) + S_L(P/F, i\%, n) - I \tag{8}$$

where

NPV = net present value

I = investment(P/A costs) for a specific period or system quality level

B_C = annual benefit or profit generated by the reduction of failure costs through a specific investment project

B_0 = annual benefit or profit generated by avoiding opportunity loss through a specific investment project

S_L = salvage value of the specific investment project

i = interest rate or internal rate of return(=IRR)

n = project life

$(P/A, i\%, n)$ = uniform series present value factor

$(P/F, i\%, n)$ = single sum present value factor

If we allow the above equation to equal zero, and solve for $i\%$, it is possible to investigate if the investment is justified. There are two possibilities ;

1. If IRR is greater than or equal to MARR, the investment is justified.
2. If IRR is less than MARR, the investment is not justified.

For potential quality improvement activities, if the above analysis is justified, it means that the quality improvement activities should proceed. However, the organization is supposed to review or suspend this quality program if there is an opposite result of comparison between IRR and MARR.

From a theoretical point of views, quality improvement activities must produce higher quality and productivity; however, it is not always true. According to the above equation (8), if the investment is not justified, some quality improvement activities may not be allowed. However, most of quality improvement activities create a lot of invisible effect so that quality improvement activities must be viewed as a cog in the overall total quality management.

4. Conclusion

This research puts into question the economics of quality improvement activities. From the exposition provided above, it is obvious that any investment under consideration by a corporation would be analyzed using proven economic methods such as capital budgeting. According to Juran's revised COQ model, zero defects give the best benefits to a corporation. However, if the quality investment does not meet the organization's MARR, 100% conformance is not economically advisable. This may be a frightening thought to some, but it would lead to the concerted decision by management, that beyond a certain level of quality, no more investment will be ventured. The highest level of quality may not be the smartest economic venture for the organization.

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