ABSTRACT

This paper illustrates the problems which arise in collecting appropriate data for a "cost of quality" exercise and evaluating the economic cost of quality. The practical measurements involve dealing with the attitudes and approaches by management to exactly what constitutes a quality cost. Many cost items can only be estimated and this adds to the complexity of measurement in an organisation. Specifically, the paper reviews the nature of the cost relationship, exploring the concept of marginal cost and marginal benefit in the quality context which should be the basis for firms' decisions about the "optimal level of quality".

INTRODUCTION

Although the terms "economics of quality" and "quality costs" are often considered to be synonymous, this paper emphasises the clear distinction between the two. The first we interpret as economic analysis applied to Quality Control and the second we interpret as the specific cost items attributable to quality improvement activities. Generally speaking, there are two main approaches to dealing with the economics of quality. Firstly, there are models which are supposed to reflect the 'economic cost of quality'. Secondly, emerging developments have a basis in systems approaches to quality costs. This paper seeks to illustrate the problems which arise in collecting appropriate data for a "cost of quality" exercise and evaluating the economic cost of quality. The practical measurement of quality costs involves dealing with the attitudes and approaches by management to exactly what constitutes a quality cost. Many components of quality costs can only be estimated and this adds to the difficulty in applying the economic models of analysis in an organisation. Turner (1969) explained that there were too many variables to illustrate the situation graphically. Other writers have commented on factors which have a bearing on the determination and use of quality costs. For example, Bajpai and Willey (1989) indicated that since data on quality costs are elusive, many companies are unable to identify real benefits which can accrue from improving quality. Essentially, what organisations are looking for in a practical sense is the achievement of cost reduction as illustrated in figure 1:
Organisations are likely to use accounting cost principles rather than economic cost principles in deciding on their quality level. For example, opportunity costs will generally not be taken into account. In quality terms, activities such as doing things twice could be included as opportunity costs as the staff concerned are not available for other tasks (there will be lost production) whilst they are correcting failures.

However, before the practitioner can use the model as a management tool, it is essential that the subject organisation (department or company) is geared to providing information. The problems identified in the two organisations featured in this paper include consistency in data collection, verification of the data collected and adding a 'real' value to the data.

**ECONOMIC COST OF QUALITY**

Juran (1951, p8) discussed the 'economics of quality of conformance' when he first offered a model which showed the 'economics of quality'. He fully recognised the economic dilemma:

"...the basic quality problem ... is to strike the optimum balance between cost of quality and value of quality for each quality characteristic ...."

He argued that increased conformance reduces the losses due to defectives and states that "the cost of the controls needed for greater conformance rises geometrically as perfection is approached". This reflects the economist's perception of falling marginal returns (to added quality effort) and from this we can deduce (when we also consider that marginal benefits from added quality effort are likely also to decline) that perfection will not be achievable - let alone optimal! Since Juran's paper there has been a great proliferation of notional or conceptual models based on Juran's work and these very often relate costs in dollars to the quality of conformance - from 100% defective up to no defectives at all. There are, however, very few explanations as to how the economic models are supposed to work in practice.

Gryna analyses the differences between Juran's early model and his later (1988) model. Figure 2, below, represents the recent preference to concentrate on prevention rather than on internal failure. Gryna's model suggests that perfection can almost be reached in an economic manner in that the costs of appraisal plus prevention are finite not infinite.

Sittig (1963) not only explained 'the economics of quality', he also dealt with 'the problem of optimal quality' and introduced aspects of 'the dynamics of quality'. In this paper he says: ".... the difference between 'production costs' and 'quality costs' is entirely artificial. Quality costs do not exist as a category opposed to production costs and therefore strictly speaking, do not exist at all. This does not mean that it is unimportant to analyse the relationship between cost and quality. On the contrary this relationship has been the pivot of our theoretical discussion ......"
A number of issues emerge from this investigation of the literature, including the lack of real economic models of quality and cost - as most tend to be notional models without supporting evidence. Turner (1969), following methodologies from economics, illustrated the relationships between 'quality of conformance' and 'dollars' as well as 'the amount of inspection and quality control for operations' and 'unit cost - dollars'. Both of these illustrate that the "optimum" point at maximum total cost is not the same as the break even point of the other curves. Turner's key contribution was to discuss quality costs in economic terms such as marginal cost and marginal revenue but the quality cost curves, although depicted this way, are rarely supported by evidence.

As can be seen from Juran's initial models, the costs of improvement continue to rise whilst the costs of failure continue to fall (again this illustrates the principle of diminishing marginal returns in both benefits and effort). For a regular decision about how much to produce, the Marginal Cost curve illustrates the additional cost incurred by the firm to produce one more unit of output. (In practice, the output units do not have to be single and judgements have to be made in relation to unit or batch size.) A firm should produce where Marginal Revenue is equal to Marginal Cost but when profit is less than zero it may be preferable to shut down rather than continue. The shut down rule is "if for every choice of output level the firm's average revenue is less than its average cost, the firm should shut down" (Katz and Rosen, 1994).

The key point to this decision is, of course, the distinction that needs to be made between short- and long-run costs and revenues. In the short-run losses may be tolerated because of the expectation of making long-run profits but long-run losses can be expected to lead to shut down.

In the following figure (adapted from Katz and Rosen) the firm should continue to produce output.
However it must also be mentioned that some leading authors such as Feigenbaum (1961) ignore this type of economic analysis. Philip Crosby in 'Quality is Free' (1979, page 16) dismisses it as an "erroneous assumption" and states: "We mustn't get faked out by words that have no meaning, and 'economics of quality' certainly has no meaning". Plunkett and Dale (1988) suggest that diagrams showing a relationship between quality effort and costs are misleading, at least for many quality management practitioners.

ORGANISATIONS AND THE ECONOMIC COST OF QUALITY

Aspects of the economics of quality include the attitudes and approaches by management to the quality problem and this section outlines some of the organisational factors which contribute to determining the optimal quality decision. Gupta and Campbell (1995) explained that not all companies measure the costs of quality. They showed that only five out of the 22 companies in the final round of the 1991 Malcolm Baldrige National Quality Award calculated quality costs. Most importantly, they stressed that the barriers to introducing prevention programmes were behavioural rather than economic because they "require vision, innovation and a break from the status quo."

One underlying principle in dealing with the economic side of quality is that failure costs are assumed to be higher than prevention (and appraisal) costs. Elshazly (1999) dealt with accounting for quality costs and provided an outline of seven lessons from the accounting aspect. One key lesson is that if a company wants to reduce its quality costs and enhance its product and service quality, then it must be willing to spend more money on prevention, because there is an obvious trade-off between prevention and appraisal along with the internal and external failure costs. Elshazly explains that the underlying premise that failure costs exceed prevention costs...
means that, as prevention costs increase failure costs will drop. The main thrust of the argument is that the accountant can help provide company-wide costs of quality in a number of different ways, including management involvement and adapting accounting systems meaningfully.

In his 1998 paper Kume states that "many companies treat the economic problems pertaining to quality as quality costs". Kume explains that this is not the way things happen in practice and management should not be concerned with these costs but should try to minimise the loss using quality management. For example, changes in what the workers were actually doing in a sub-process in a car manufacturer rendered the whole process sub-optimal. His view is that when loss prevention and the development of new business and sales (which are just two parts of a company) are well balanced, a company can maximise long-run profit.

Burrow and Medolta (1999) argue that "the cost of quality concept has lost some of its popularity in recent years and nothing more comprehensive has evolved to replace it. It is also evident that senior manager's may not have learned the lesson from the past." One example of this can be found in Stewart's (1999) article which features an interview with Joseph Juran who discusses the case of Xerox who, despite knowing the nature of the problems that they were facing, were continuing to put forward aspects of their management policy and not address the key problem issues. Xerox lost large amounts of money during a warranty period and when Juran asked to see the previous ten most frequent field failures, it was discovered that they were the same as the present most frequent field failures. Thus Xerox were collecting information about failures but doing nothing about the problems.

Other methods relating to modelling the problems have been developed and suggested throughout the literature including work by Krishnamoorthi (1989) who discusses the use of regression in relation to the quality cost changes and the interrelationship between the four elements - prevention, appraisal, external and internal failure. He explains that this interrelationship is quite complex - which is probably an understatement.

Types Of Models

Plunkett & Dale (1987) state that "a most striking feature of the literature is a preoccupation with prevention-appraisal-failure categorisation, even though it is shown that arrangements into these categories tends to be a post-collection exercise carried out to accord with convention." They go on to explain further that "many writers state or imply their definitions of quality-related costs. In other cases, it is evident from the text or figures that the writers' view of what constitutes a quality-related cost is at odds with commonly accepted views."

Although it could be argued that prevention costs should fall over time, it is difficult to group appraisal and failure together. This can be borne out quite simply with Juran's (1951) model of and the work of Blank and Solorzano (1978) where their model shows a distinction between discretionary and consequential costs.

Another view emerging (Jamieson 1989) is that it is not really possible to determine an optimum level for quality in these models. Foster (1996) set out to examine the relationships between conformance and quality related costs where prevention and appraisal are linked. Foster's discussion clearly shows that organisational learning and training and education will have an effect on what happens in organisations. Despite what Juran said in 1951 that "The facts on cost of quality are often precisely ascertainable", the collection and classification of quality cost data does cause great difficulties and as such the true costs may not be reflected in some of the models being used (Eldridge and Dale 1989).

The argument also emerges that the use of failure costs externally is a key area. In 1978, Brown and Kane said that ".......every dollar of improvement in reported failure costs is likely to result in several dollars improvement in profits. In many instances this kind of payoff is more fruitful than the more traditional efforts to reduce direct product labour or material costs". Campanella & Corcoran (1983) made the point that an increase in the cost of prevention should actually result in a decrease in the cost of failure. However, this decrease should be larger than the cost of failure than the cost of prevention and total quality costs would be overall reduced.

Empirical evidence
From the examples and issues highlighted above, it seems improbable that, in 'real life' company situations, quality costs would be ignored when they were vital for improvement. The following examples illustrate the micro aspects of what prevents the achievement of the improvements indicated by Juran and others.

Example A.
This case involves an organisation which provides steel industry related products. At times the product mix did not reach the required quality. The production system involved a number of sub-processes the first of which was weighing and blending the powder materials in the appropriate 'recipe' for a batch. This material was then mixed with binding agents before it was processed further. The next stage involved a solvent system, heating and drying before the mixture was allowed to cool and then tested before going on to the next sub-process of moulding and iso-static pressing. The problem was that the output from the initial stage was not up to standard and could not be processed further. The symptoms appeared to be caused by atmospheric conditions (humidity arising from the situation of the factory on a hill top). However, by using cause and effect techniques the root cause of the problem was identified. It emerged that the blades in the mixing drum were damaged through wear and a massive material build-up prevented proper mixing. There was no preventative maintenance programme and as there had been no engineering breakdown the problem had not been noted. Three months or more later the problem still existed. However, what was most telling about this organisation was that after identifying the problem, formulating a solution, and communicating the situation to the senior management team, it was allowed to continue without remedial procedures being put into place.

Example B.
The second example involves a printing firm. After a study over a number of months, customers’ complaints were analysed. These were examined and categorised and agreed by senior managers. The rank order was then used to prepare a Pareto analysis - in order to address the problems systematically. The main categories included colour problems and die cutting. Agreeing the nature, explanation and categorisation of each complaint involved examining written reports (normally one sheet with main details), discussing the issues with managers and Directors and the compilation of a brief report to instigate action. The key issue which emerged was that the CEO did not agree with the other’s analysis and definitions. This meant that categories of complaints were addressed in a very different order. As in the Juran example above, the same quality problems were repeated.

DISCUSSION AND CONCLUSIONS
It would appear from investigation into the literature and models that although the new model put forward by Juran and Gryna (1988) is certainly different from the older more established approach, it indicates that things will stop. Notional models have emerged in much of the literature from Juran's early interpretation and many variations of this have been used as a kind of 'break-even' situation where the costs of failure will, at some point, equal the costs of prevention and appraisal. Consider also the following conceptual model which indicates that the costs do not necessarily act in a curvilinear manner as previously shown. What is more likely is that costs become incremental and are allocated over time. Therefore, they would be stepped ("quasi-discrete") as production output remains stable. Thus, as good quality increases in the output, then the cost per unit would drop but, at the same time, more may be expended as time progresses. This would have the effect then of improving quality and, in fact, cutting the costs of failure, thus, there would be an optimal level over time. (This bit is unclear – see at the end) Once this is reached it would be beneficial to maintain as opposed to showing the model as continuously rising failure costs and continuously decreasing prevention and appraisal costs. On closer
examination, what we have is a 'grey area', which is similar to Taguchi's Loss Function approach (see Kim and Liao, 1994) and, also, Juran and Gryna's 'optimum quality curve' (1988).

Example A above illustrates that it is necessary to target prevention activities or improvements will not be achieved - this company kept producing despite economic evidence! In example B, the company was achieving incremental improvements but, without definition and targeted data collection, it was not possible to define improvements - because they would not be tackling the root causes of the complaints! Thus internal agreement and joint effort would have to be achieved to maximise efforts in an economic sense. As in the case of marginal revenue and marginal costs, there comes a point when it is not viable to continue to spend more on prevention and appraisal. However, depending on the situation in the organisation (indicated above), there may be no other choice as quality may not be at the desired levels.

The debate on how to deal with quality costs will continue for some time to come. It is clear from the literature that some experts in the field feel that quality costs are a thing of the past. It is also clear from others that the lessons are not being learned and organisations continue to do things wrong despite knowing the consequences. The economic models of quality in the literature are mainly notional - not borne out by data. The reasons for this include the complexity involved in quality cost related activities, the issues of data collection and the interpretations of data. In the course of this study, one organisation embarked on a series of experiments involving more that 25 variables. This took several months but did not provide useful conclusive results. Although the end objective may be the same as that illustrated in Figure 1, in order to understand some of the economics it is necessary to understand the process under study, to gather data and allocate costs. This, in some organisations, can be very difficult (if not impossible) and economic analyses as such were not considered by the organisations in this study.

REFERENCES

Is my understanding correct: The incremental costs are incurred as a result of ad hoc increases in prevention and appraisal costs which are taking place in an unplanned and unscrutinised way. There is only limited benefit to be achieved by this, because the people who are initiating the changes do not have the overview of costs and benefits. The consequence is that they may continue to bring about their incremental changes, and hence increases in costs, long past the point where the benefits are exceeded by the costs. Is this another example of Deming’s problem with people “doing their best”? 

I just found the explanation a bit unclear.