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Srinidhi, Bin;Balachandran, K R
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Strategic positioning and cost management along various quality dimensions

K.R. Balachandran
New York University, New York, USA and
Bin Srinidhi
Rutgers University, USA

Introduction

Increasing pressure of global competition and a significant increase in customer awareness have made quality management one of the most important strategic concerns of firms in the USA. Traditionally, managers have thought of quality as a "good" that can be bought by incurring more costs. This view has been reinforced by economists and management theorists for some time. Recently, however, there has been some evidence that the total lifetime costs to the firm might actually decline when the product quality is improved. For example, a perception of low quality in a competitive environment might impose significant opportunity costs of lost sales in addition to the normal costs of low quality such as warranties, waste and rework costs. In such a situation, improving the quality by using superior designs and superior production processes might actually result in lower total costs. Crosby[1] makes this point forcefully when he states that quality is free and lack of quality is costly.

In this paper, we provide a structure under which we can view the traditional "goods" view of quality and the complementarity of cost and quality as different manifestations of the same underlying phenomenon. We also synthesize the many operational definitions of quality such as conformance quality and performance quality which have been proposed in the literature. Apart from facilitating an explicit formulation of strategic objectives and policies, such a synthesis improves the clarity, reduces the confusion and provides a focus for improvement efforts. Moreover, we provide a rationale for dynamic adaptations of changing quality concepts in a firm.

Quality can be perceived and operationalized in different ways. The most pervasive understanding of quality in manufacturing organizations is one of conformance quality. This means that the attribute or variable of interest has a design specification and tolerance limits. For example, the gap between the hood and the body in a car might have a 2mm design specification and a tolerance limit of 1.5-2.5mm. The weight of the active ingredient in a tablet

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might have a design specification of 100mg and a tolerance limit of 99.5-100.5mg. The colour of a decorative silk plant has a design specification of dark green and will be considered non-conforming if the shade of green is significantly different in some parts as compared with other parts and the specified standard. These are all examples of conformance quality. Conformance quality specifications are usually internally set and are updated at specified intervals or when the technology changes. Performance quality, on the other hand, refers to the degree of customer satisfaction with the performance of the product. In the case of the tablet mentioned above, performance quality might be specified in terms of the effect it has on a patient. In general, performance quality specifications are customer based and are updated not only when technology changes, but also when customer expectations change due to greater awareness or changed competitive environment. Schuler and Harris[2] and Garvin[3] give a brief description of the processes and dimensions of quality.

Exceeding the conformance quality specifications does not necessarily increase performance quality. In a syndicated automotive study offered by Strategic Vision Inc. in 1994 (called Vehicle Experience Study in which about 2,600 respondents were surveyed) on ten subcompact cars, Corolla was ranked No. 1, Tercel was ranked No. 4 and Neon was ranked No. 9 on conformance quality, defined as things gone wrong (TGW). However, when overall customer satisfaction including perception of initial quality, general satisfaction and repurchase intent were considered, Corolla went down to No. 3, Tercel went down to No. 10 and Neon ranked No. 1. To illustrate further, the conformance specifications for a room air-conditioner may call for cooling a specified size of room to 68°F in three minutes. Cooling even faster may be deemed as "exceeding the conformance specifications". Such a drastic cooling is not likely to increase the comfort of the user and therefore, he/she will not be willing to pay for the cost of such a feature. In this case also, the performance quality was not increased by exceeding the conformance specifications.

A more comprehensive view of quality is to define it in terms of total lifetime cost. Taguchi propounds[4] that the cost imposed on the customer because of product quality problems will eventually be borne by the firm in the form of opportunity costs of lost sales, lost reputation and lower prices. For example, consider a car which costs US$8,000 to make but which will result in customer costs of US$5,000 in needed maintenance, repair, lost time and annoyance. Now, if by incurring additional preventive and appraisal costs of US$1,000, the manufacturer can reduce the future customer costs to US$2,000, this would be considered an improvement in quality. In this case, the firm can view the improved quality as having a cost of US$1,000 for the firm or alternatively, it can view the improved quality as having reduced the cost by US$2,000. The first view would be a traditional view of quality as a "good". The second view recognizes the complementary nature of costs and quality and is consistent with Taguchi's view of quality. This concept can be further expanded to include not only the costs to the customer, but also the costs to society. For example,

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consider the case of Tylenol capsules which were tampered with resulting in some deaths. In this case, Johnson and Johnson, the manufacturer of Tylenol, was not aware of the possibility of such tampering. All the same, once the problem occurred, they had to withdraw the capsules and take a number of steps to ensure that the products are not easily tampered with. The cost imposed on society, albeit unknowingly, resulted in a higher cost to the firm.

The management's strategy on quality depends on its perceived costs of quality and the definition of quality internalized by it. If the management does not view the costs imposed on the customer as costs to the firm, the decisions made by it on quality management level is different from a management which views them as such. A useful way to quantify the management viewpoint is through the "cost of quality" framework suggested by Feigenbaum[5] and developed by Juran[6] and Juran and Gryna[7]. In this framework, four classes of costs related to quality are defined. Failure costs are costs resulting from lack of quality. Of these, internal failure costs are costs of scrap and rework which result when the defective units are detected before being shipped to the customer. External failure costs refer to the costs resulting from sending defective items to the customer. These include warranty and repair costs as well as management's estimate of opportunity costs of lost sales and reputation. If the management believes that all the costs borne by the customers because of the firm's product will be reimposed on the firm, its perceived external failure costs will be high. On the other hand, if the management views most of the costs borne by the customer as independent of future sales and reputation, its perceived external failure costs will be low. The third class of cost of quality comprises appraisal costs. Appraisal costs include all the costs of inspection and identifying the nature of defects. The fourth class is the cost of prevention. Prevention costs are costs incurred to improve process yields and include design, training and statistical process control costs. Under this framework, it is necessary to have a cost accounting system which separates out the cost of production from the costs of quality. For example, training of employees might include training to increase production, training to focus attention on the likely places where defects might occur, training to inspect and training to design or redesign. These costs will have to be allocated to costs of production and costs of prevention (quality). The complete framework of costs of quality and the accounting systems needed to implement it are discussed by Radhakrishnan and Srinidhi[8].

Relationship between perceived costs and conformance quality

In this section, we give greater specificity to the relationship between the costs of quality and the quality measures. Figure 1 presents the basic relationship between conformance quality and total costs. The traditional management view of quality, in which the improvement of quality is necessarily accompanied by an increase in out of pocket costs, is confined to the first part of the curve (marked part 1 in the figure).

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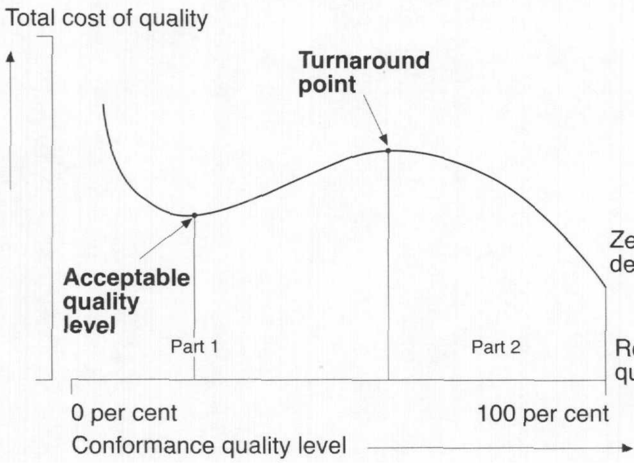

Figure 1. The basic relationship between conformance quality and total costs

It is important to note here that every point on the curve is an efficient point. In other words, every point is the lowest cost of quality with which the corresponding conformance quality can be achieved.

The first part of the relationship and acceptable quality level (AQL)

In this part, there is a trade-off between the conformance quality and the costs of quality. As conformance quality is increased, the costs of failure (both the internal costs and external costs) decrease but the appraisal costs and preventive costs go up.

In fact, for a given prevention level, an increase in appraisal activity increases internal failure costs but decreases external failure costs. Correspondingly, the output conformance quality increases although the inherent conformance quality remains the same. In other words, the interactions can be pictured as follows. The prevention activity (and its corresponding prevention cost) determines the inherent conformance quality level which acts as the floor of the output quality level. The level of appraisal determines the improvement from inherent quality to output quality – the more the appraisal, greater the improvement will be. Correspondingly, this improvement is costly in terms of increased appraisal and internal failure costs. It is beneficial in terms of decreased external failure costs.

At very low levels of conformance, the failure costs are very high and dominate the costs. However, as better designs, statistical process control measures, vendor certification (all preventive costs) and better inspection and screening procedures (appraisal costs) are put in place, the failure costs decrease faster than the increase in preventive and appraisal costs. After a certain level of conformance, the marginal benefits of preventive and appraisal efforts (in terms of decreased failure costs and increased productivity) are outweighed by their additional costs. At this level of conformance, the total cost starts increasing. This minimum level is called the acceptable quality level

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(AQL) and is really a local minimum. Traditional view of management, supported by operations management theories, treats this as the global minimum and chooses this level for directing their quality improvement effort. An AQL of 99 per cent means that not more than 1 per cent of the units produced are defective. Movement to the AQL consists of achieving both the lowest total cost for any conformance quality level and choosing the quality level at which the local minimum occurs.

Cost accounting systems for AQL

In general, determination of this optimization is possible only if the cost accounting systems are designed to give reasonable estimates of the four classes of cost of quality. The cost accounting system should distinguish between activities which are predominantly prevention or appraisal activities and activities which are predominantly production or sales activities. Then, the system should appropriately assign costs for prevention and appraisal activities. In addition, the accounting system should separately identify costs of internal and external failures. For example, if there is a rework job, the cost accumulated by the job costing system for the rework job should be classified as internal failure cost if the rework is the result of internal inspection, but should be classified as external failure cost if the rework is being done to satisfy a customer demand. For example, the costs of recall and rework on recalled models in the automobile industry are external failure costs.

The turnaround point

Quality improvement efforts beyond the AQL usually involve processes and systems as well as changes in management and employee attitudes. For example, consider the process of vendor selection. The traditional method of vendor selection is to give a specification and ask for bids from various vendors. The lowest bid is generally accepted. In view of the cost of quality framework, this gets modified into selecting a vendor such that the total expected cost of purchase, inspection and possible failure is minimized. We can now think of a totally different procedure for vendor selection. Consider presenting only the basic performance details of the required part a few years in advance of the requirement. The future vendor is selected on the basis of whether he/she is willing to work closely with the company in the part to satisfy the performance specification at a target cost. For agreeing to do this, the vendor is guaranteed of the order for a long term. Under this scenario, the expected future cost of the part is often lower than the minimum that one can get in the market for a pre-specified part. Moreover, target quality can be built into the product so as to minimize future appraisal and failure costs. The process employed by Nissan Motor Manufacturing Company to manage down the costs for a given performance characteristic and given quality level is described by Balachandran and Srinidhi[9]. By changing the process of managing the cost, the firm has now been able to achieve higher quality at a lower cost.

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The example given above is for a change in the vendor selection process. There have been many documented successes of both quality improvements and cost reductions resulting from re-engineering the processes. Hammer and Champy[10] discuss the case of IBM credit approval process which consumed six days on the average, involved a long sequence of required procedures and often resulted in loss of sales. It was re-engineered to accomplish a 90 per cent reduction in cycle time and a hundredfold increase in productivity. They also report similar changes and improvements in Ford vendor payment system and Eastman Kodak's new product development process. In all these cases, process changes involve empowerment of the employees to suggest and implement improvements, much greater training in process co-ordination, improvement of teamwork and group projects and applications of information technology changes which could not earlier be implemented because of departmentalized structures and unfocused, often conflicting, individual objectives in the organization. This allows processes to become simpler, employees to be more involved and can result in a reduction in the information asymmetry among the employees.

These re-engineered processes result in much lower costs and improved quality. The stage at which this starts happening is labelled in Figure 1 as the "turnaround point". Beyond the turnaround point, there is increasing recognition that cost and quality are not necessarily traded off. In fact, improvement of quality becomes the main driver for cost reduction. This essential complementarity between costs and quality gets used in systems such as target analysis. The part of the graph following the turnaround point (marked part 2 in the figure) demonstrates the complementary relationship where the quality is improving and cost is decreasing. In fact, at this point, the management's perceived external failure costs are generally much higher than their perception in the first part.

Operationally, if a firm has moved to this part of the curve, it might become detrimental to keep emphasizing the trade-offs highlighted by the cost of quality framework. Therefore, while cost of quality framework is useful in moving the management towards and beyond the AQL, its usefulness as a management tool decreases in the range beyond the turnaround point. In fact, the management perception of external failure costs (not accurately determined by cost accounting methods – mostly subjective) would have gone up and the actual costs of internal failure and appraisal would have gone down. Most of the quality management decisions would involve the selection among different prevention efforts and methods. The cost of quality framework is not very useful for this purpose. This decreasing importance of cost measurement is consistent with Deming's philosophy[11] that detailed cost measurements and quantitative measures of performance are actually damaging to the firm. Note that in our framework, the detailed cost measurements and quantitative measures served a very important purpose – of educating the management. We believe that Juran[6], in advocating the cost of quality framework, was speaking to an audience of traditional managers who needed to be convinced of the

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benefits of quality improvement *vis-à-vis* the costs. On the other hand, Deming, in exhorting managers to drop quantitative performance evaluation and cost measures, was talking to an audience of managers who had moved beyond the turnaround point.

The zero defect (ZD) point

The zero defect point under conformance quality is the point where all the units conform to the design and tolerance specifications. It should be noted that zero defect concept does not imply that the number of errors is reduced to zero. It is difficult and often impossible to reduce the number of errors and mistakes to zero. However, by building in source inspection, mistake proofing and other corrective systems, it is often possible to neutralize the effect of errors and prevent them from becoming defects. The use of zero defect as a goal not only focuses attention on the reduction of errors but also on systems to prevent errors from becoming defects. Shingo[12] presents and describes this view in detail. The complementarity of cost reduction and quality improvement naturally leads to the zero defect point as the lowest cost point. Logically, therefore, a zero defect conformance quality is a desirable point for achievement. If the cost level under zero defect is lower than the cost level under AQL, this is preferable over the AQL. Strategically, this is the desired point to achieve in most situations.

Robust quality

Taguchi and Clausing[13] document the concept of robust quality. There are two dimensions of robustness which are emphasized in Taguchi's writings (see Taguchi and Wu[4]). The first is the ability of the product to endure abnormal uses of the product. A detailed example of such a concept is given in Figure 2. For example, neither a watch is generally built to withstand falls nor is a regular camera made to survive accidental immersion in water. The ability of a watch to withstand a fall or the ability of a camera to endure being immersed in water are examples of this dimension of robust quality. Even a very reliable

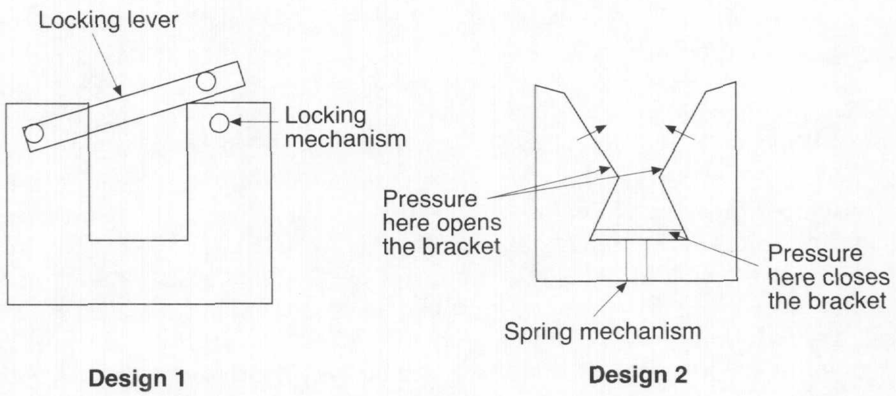

Figure 2.
Robust quality

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performance under normal operating conditions does not ensure that the product is going to operate under extreme or abnormal conditions.

An example for robust performance quality. This example is about a manufacturer of motorized carousels which are used in displaying carpet rolls. The carpet rolls are mounted on two brackets at the ends. The brackets bear the load both when the carousel is static and when the rolls are moving. The firm was using design 1 which is shown in Figure 2. The end of the stem holding the carpet roll sits in the bracket at the time of mounting. After placing it there, it is locked into place by pulling down the locking lever. The bracket is made of strong steel and is designed to have a factor of safety of 4, i.e. the load of the carpet roll can increase to four times the normal load without fracturing the bracket. The design is such that the thickness of the bracket can be increased and if needed, the factor of safety can be further increased.

There is a competing bracket design (design 2) that is available in the market that has been used by some competitors. This design is shown on the right hand side in the figure. In this case, there is a spring mechanism in the bracket which opens when the carpet roll is placed on the bracket. The stem falls into the bracket and the spring mechanism automatically closes the opening in the bracket. There is no separate locking mechanism that needs to be operated. For the spring mechanism to work at low carpet roll loads, the bracket has to be kept thin. The factor of safety is about 1.5 and cannot be significantly increased from the current level.

The question is which one of these two constitutes robust performance quality design? A survey of the customers indicated that they preferred design 2 even though it had a lower factor of safety. The customers are carpet retailers such as Home Depot and Builders Square who employ unskilled labour for mounting carpet rolls. The likelihood of the worker not properly closing the lock is significant in design 1. Design 2 eliminates this possibility by not requiring the worker to use the lock. If the carpet stem is not locked into position, there is a small but non-trivial probability that the carpet roll "jumps out" of the bracket and creates safety problems for personnel near the carousel. It is not the load-bearing ability that is foremost in the customer's mind but the issue of the consequences of "unspecified" or abnormal use. Design 2, therefore, satisfies the criterion of robust quality but design 1 does not.

The second related dimension of robustness that Taguchi develops is the reduction of variability of components. This is the ability of the component or the part to perform adequately even if the underlying design parameter has drifted significantly. Kacker[14] gives an example of designing a circuit to give a specified voltage. In that case, the output voltage is a non-linear of the transistor gain which is a design parameter. The transistor gain is selected at a point where the output voltage is not sensitive to the gain even though that is not the required mean voltage. The circuit design is then modified to transform the voltage to the required level. We view this dimension of robustness as an integral part of the performance quality concept. The customer is still operating the product the way it should be, but the design parameter has

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shifted. The output should still be satisfactory to satisfy the customer. This is different from the setting in which the customer uses the product in a way it was not meant to be used.

Robustness under conformance is defined as there being no acceptable level of deviation from the target specification. A lack of robustness under conformance does not necessarily imply a lack of robustness under performance quality or vice versa. For example, the watch or the camera might still perform satisfactorily even though their production may not have robust conformance quality. On the other hand, a room air-conditioner which cools the room too fast may conform to robust conformance quality but may not have a good performance quality.

Robust quality measure must exceed the measure under zero defect. Zero defect under conformance means that every unit of the product is built to be within the specified tolerances. Robust conformance quality requires that tolerances be zero. Even where the policy calls for zero defect conformance quality for the assembled product, it may be necessary to require robust conformance quality for subassemblies, since any allowed tolerances for the subassemblies may cumulate to make zero defect conformance for the assembled unit unattainable. If we use Figure 1 for a subassembly, the robust conformance quality is to the right of zero defect. The corresponding cost will be increasing if we ignore the benefit of improved quality of the assembled product. If we incorporate this benefit, the net cost of robust quality may actually be lower than the cost of zero defect. As a second example, increasing the conformance quality beyond zero defect to robust conformance quality may result in increased net cost if the customers do not perceive any difference in the output produced with or without tolerances.

Relationship between perceived costs and performance quality

In view of the fact that conformance quality is clearly measurable as the degree of conformance to a set of identifiable design specifications, the definitions of AQL, TP and ZD do not pose any particular problem. However, performance quality measure has more to do with customer satisfaction with the product performance than with design specifications. Instead of degree of conformance on the x-axis as in Figure 1, performance quality needs to be measured. Possible measures include the percentage of customers satisfied, the number of customers satisfied weighted by their purchases and results of surveys in which customers can rate the levels of satisfaction. At a broader level, market share might also be a reasonable indicator of performance quality. An implication of defining quality in terms of performance quality is that it requires the voice of the customer to be brought in explicitly in the quality management function. Quality function deployment (QFD) is one methodology to achieve this. For a discussion of how QFD gets applied in service and regulated industries, see Dutta *et al.*[15]. Figure 3 puts the performance quality measure on the x-axis and the total costs of quality on the y-axis. The shape of the graph remains the same as in Figure 1.

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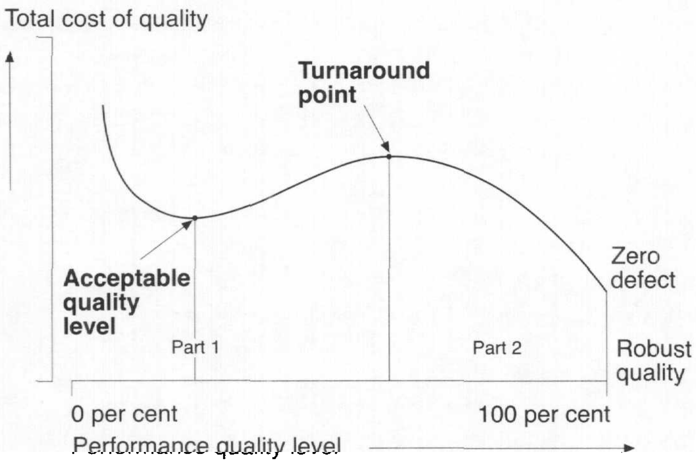

Figure 3. Relationship between total costs of quality and performance quality

At low levels of performance quality, the failure costs, particularly the external failure cost, will be very high. Improvement of performance quality, in terms of customer satisfaction, necessarily reduces expected costs of external failure but requires preventive and appraisal activities at a higher level. One main difference between the preventive costs under conformance and performance quality notions is the increased role of customer support, customer education and customer awareness activities. These activities directly improve customer satisfaction and therefore, should be considered preventive activities under performance quality notion. Under conformance quality notion, however, these activities have no direct effect on conformance quality, though they might have some indirect effect through feedback and corrective action. In the same vein, appraisal activities under performance quality notion would include the appraisal of customer satisfaction by survey, appraisal of customer satisfaction with competitors' products, internal control to detect faulty billings and such. Internal failure costs will include the cost of rectifying faulty billings, reworking on the customer site, etc.

Another important difference between the conformance and performance quality notions is the degree of control that the managers bring to bear on quality levels. In changing conformance quality levels, they deal mostly with parameters which are amenable to their control. In order to change performance quality levels, they need to manage customer expectations. Customer expectations are driven not only by the organization in question, but also by competitors, global accessibility of products and information, technology levels and other parameters which are not under managers' control. Therefore, not only is there a greater uncertainty and subjectivity in the performance quality measure, but also a lack of control and potential radical changes over time.

Given these differences, there is still an acceptable performance quality level at which the costs of failure are traded off with the costs of prevention and appraisal at the margin. This AQL is different from the AQL under conformance

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quality criterion because of the difference in definitions of the costs. Firms often find themselves in an environment where further increases in customer satisfaction (performance quality) are more costly than the benefits derived. However, a sustained continuous movement towards increased performance quality can change the business environment in such a way that further increases in quality actually decrease the cost. This is usually the point at which customers start to develop a strong loyalty to the product, and to the firm. As before, we label this point as the "turnaround point". Theoretically, the zero defect point under performance quality notion is the point at which all customers are satisfied with the product and fully loyal.

The robustness under performance quality notion is defined as very strong customer loyalty. For example, when Toyota introduced the Avalon model, customer loyalty to Toyota products was robust enough to create a high quality image for this new product. Maintaining such robust performance quality requires the firm continuously to exceed customer expectations.

On the performance criteria, in Figure 3, robust quality is again noted to the right of zero defect. The total cost may decrease, if the customers appreciate the robustness (for example, the unit working after abuse) and pay for it in terms of increased price or increased brand loyalty. The net cost may increase if the customers are either indifferent to the increase in quality or even prefer a different design because of convenience or appearance or other factors. Figure 2 gives an example where the customer prefers robust performance quality in the design of the product and is indifferent to robust conformance quality.

Strategic positioning within the quality concept matrix

Table I presents a matrix of the different concepts of quality that have been discussed in the form of a simple matrix. First, management's concept of quality will be described better either by a conformance approach or by a performance quality approach. These two quality concepts form the two rows. Second, the level of quality that management wants to achieve is given as columns. AQL is the quality level that managements would like to achieve under the cost of quality framework if they view costs and quality as trade-offs. ZD is the quality level that they would want to achieve if the managers are convinced of the complementary relationship between cost reduction and quality improvement. That leaves us with the question of when managers would prefer to design products with robustness. Therefore, robust quality is added as the third column in the matrix.

An acceptable conformance quality level is achieved when the degree of conformance of the product to design specifications is at a level when the total measurable cost of quality is minimized given the current product and process designs, current level of information technology, current management system and a given organizational culture and leadership style. Similarly, an acceptable performance quality level is achieved when the degree of customer satisfaction of customers with the performance of the product is at a level when the total cost of quality is minimized subject to the same constraints. A ZD conformance

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	Acceptable quality level	Zero defect	Robust quality
Conformance quality	*The concept:* The average proportion of parts which conform to the design specifications such that the estimated marginal cost of failures = estimated marginal cost of prevention and appraisal.	*The concept:* The marginal cost of failures is deemed high enough so that the optimal quality level is when all all the parts produced conform to the design specifications.	*The concept:* Not only should 100 per cent of the parts conform to specification but no deviation from the desired specification is allowed.
	Example: The tolerance for the part is 12"±0.05". 95 per cent of the parts fall in these tolerance limits. This is where the marginal cost of failure = marginal cost of prevention and appraisal.	*Example:* The tolerance for the part is 12"±0.05". 100 per cent of the parts conform to these limits. Management feels that the cost of even incidental failure to conform is large enough to warrant more prevention and/or appraisal to reduce the number of defects to zero.	*Example:* The tolerance for the part is 12"±0.00". 100 per cent of the parts conform to these limits. Management feels that conforming to the specified limits is not enough – variability and deviations from the desired point must be maintained at zero or at least minimized.
Performance quality	*The concept:* The dissatisfaction level of the customer should be low enough at a point where the marginal estimated cost of prevention and appraisal is equal to the marginal cost of additional dissatisfaction.	*The concept:* The marginal cost of failures is deemed high enough so that the optimal quality level is when all customers are very satisfied with the performance. The only dissatisfactions noticed are those customers who did not use the product properly.	*The concept:* The part must be insensitive to changes of uncontrollable parameters and must be able to withstand unspecified uses. Customers are very loyal.
	Example: Customer surveys indicate that less than 5 per cent of the customers are dissatisfied with the colours on the TV manufactured by our firm. The management also feels that trying to satisfy more customers is not justified in terms of additional costs of prevention and appraisal.	*Example:* Customer surveys indicate that no customer who has used the product properly feels dissatisfied with the performance of the product.	*Example:* The parts are not only fully satisfying to the customers when used as per specifications but is also fully operational and provides high quality performance even when the customer uses it differently.

Notes:

(1) If the tolerance levels are set based on customer preferences, the resulting quality is performance quality even though operationally, the inspection procedure might require a conformance type of screening.

(2) A part could have acceptable performance and conformance qualities if the part conforms to specifications at an acceptable level and also satisfies customers at the acceptable level.

(3) A part could have zero defect performance quality but only an acceptable conformance quality. This happens when the conformance standards are so strict that customers do not perceive the difference between conforming items and non-conforming items (which fall within a reasonable acceptance range from the customer's viewpoint).

(4) It is not possible to have a product which has only acceptable conformance level but which has a "robust" performance quality.

(5) Clearly, a product with zero defects conformance or/and robust conformance quality could be placed in any cell in the performance quality row.

Table I. Concepts of quality matrix

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quality is achieved when 100 per cent of the products conform to the design tolerance specifications. As described earlier, ZD becomes a desirable objective only if the perceived constraints on designs, processes and culture are removed and the parameters can be changed. A ZD performance quality level is reached only if the only customers dissatisfied with the product are those who used the product differently from the intended use. A robust conformance quality refers to a product design that allows for no tolerance limits and which will ensure the survival and adequate functioning of the product under extreme conditions. A robust performance quality refers to a product which will not only deliver customer satisfaction for intended uses but also anticipates possible unintended uses and abuses and can withstand those.

Strategic positioning

Before deciding on a strategy of quality management, the company has to study its position in the marketplace. There are three possibilities the company may find itself in. First, the company finds that it can increase its market share with increase in quality of its products. That is, it finds that customers will pay for higher quality and switch brands if necessary to enjoy the higher quality products. In this case, the company will be well advised to spend more on appraisal and prevention activities to decrease the internal and external failures even if the increase in the cost is larger than the reduction of failure costs. This assumes that the company is not at zero defect or robust quality level and that performance quality criterion is used.

A second type of company finds that it can neither gain nor lose market share in the foreseeable future by any strategic playing on quality improvement. That is, the customers cannot see or feel the increase in quality. In such a situation, the company should maintain the same quality but push down the total quality cost to the efficiency frontier with continuous improvement in cost reduction.

A third type of company is worried about eroding market share but cannot increase revenue. This company should increase quality by trading off appraisal and prevention costs with internal and external failure costs and then go towards the efficiency frontier with continuous improvement. Benchmarking approaches are useful for the second and third types of companies.

Further strategic analysis of the quality management system has to start from an understanding of where in the matrix of Table I the management of the organization is currently positioned. This requires an understanding of the systems and procedures in the firm, management systems in place, the degree of empowerment of the employees, the importance given to training, the degree to which information is shared among employees and between the top management and employees, management's current understanding of the cost-quality relationships and the role of information technology in the firm. The firm is positioned in the performance quality row if the primary tools of quality management derive from the customer. It is positioned in the conformance quality row if the primary tools of quality management derive from internally

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set standards. If the management is overly concerned with short-term results and views quality improvement as a cost increasing activity, the perceived optimum is an acceptable quality level. On the other hand, if the firm is re-engineering its processes, changing the culture and is involved in continuously improving the communication among its employees, it is more likely to realize the complementarity between cost and quality. If such complementarity is realized, ZD or robust quality will be the perceived optimum. If management concerns are with extreme uses (cars driven on ice, computers working in extreme temperatures and dusty surroundings, buildings able to withstand earthquakes and hurricanes) or unintended uses (cameras used in the rain, dropping of watches, electric razors used on different voltages), then robust quality is perceived to be desirable.

The second part of the strategic analysis is to determine where to move in the matrix and how. This is shown graphically in Figure 4. For example, consider a firm which is strategically now positioned at the acceptable conformance quality cell. The purpose of the strategic analysis is to reorient the quality strategy of the firm as a robust performance quality firm. Once the current

Current management position in the matrix (example: acceptable conformance quality level) → Desirable management position in the matrix (example: robust performance quality level)

Required actions (illustrative only)

(I) Product and process design

(a) Benchmark and improve product design
(b) Use low variability as criterion for product design
(c) Re-engineer the process
(d) Use statistical process control for reducing both the special and common causes of variation

(II) Information technology and management systems

(a) Use the state-of the art information technology to support the re-engineered processes and achieve zero defect
(b) Introduce the loss function approach to reduce deviations
(c) Introduce management systems such as vendor certification

(III) Customer information

(a) Set up formal systems of getting performance feedback from customers
(b) Use customer satisfaction indexes in developing designs and in developing inspection methods

(IV) Robustness

(a) From the customers, identify the types of environments in which the product might be used and abused.
(b) Use the data collected in (a) to redesign the product

Figure 4. Strategic quality analysis

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positioning and the final position is known, the required actions become clear. To move away from acceptable quality level, one needs to remove the perceived constraints of product and process designs, the information technology, management systems and so forth. To move the firm from conformance to performance quality concept, an external customer-based focus needs to be developed. This needs formal methods of measuring customer satisfaction, surveys on how the customer might use or abuse the product, the sensitivity of the customer to various product characteristics and the like.

Future research

In this paper, we have focused on different concepts of quality and how these differences are likely to influence decisions regarding the management of quality and cost. Many questions which are raised by this study need to be addressed by future research. These research questions are of two types. First, there are measurement issues which need to be addressed to get a clearer understanding of the phenomena. Second, there are many linkages between managerial actions and outcomes and between the outcomes in the short run and the outcomes in the long run. Some of these research questions are mentioned here.

The measurement of performance quality, as defined here, is more complex than the measurement of conformance quality. Moreover, there could be multiple measures of performance quality. For example, the percentage of customers satisfied by the product is one measure. This measure does not capture the intensity with which the customer likes the product and the additional value that the customer places on the product because of the relatively higher satisfaction. Circumstances under which the performance quality could be estimated by simple measures like the percentage of customers satisfied, market share, the share of the customers' purchases need to be researched into. Similarly, the measurement of robustness under conformance and performance notions is a researchable measurement issue. Cost measurement for the purpose of assessing the nature of relationships between cost and quality is another researchable issue. This includes the optimal ways of allocating the cost between production, marketing and quality, the design of accounting systems to relate the cost of failure to the appropriate job (which might have been produced much earlier) and the estimation of preventive and appraisal effort efficiencies. The nature of linkage between the quality of a part and the quality of the product, the feasibility of applying the notion of performance quality to parts rather than products, the linkage between errors and defects and design of systems to make the product robust to internal errors are examples of linkage and process research. Analytical and empirical examination of whether the company can increase its market share by improving quality or whether the company should cost manage are possible studies in the strategic area.

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Conformance quality

The concept

The average proportion of parts which conform to the design specifications such that the estimated marginal cost of failures = estimated marginal cost of prevention and appraisal.

Example

The tolerance for the part is 12 (0.05". Ninety-five per cent of the parts fall in these tolerance limits. This is where the marginal cost of failure = marginal cost of prevention and appraisal.

The concept

The marginal cost of failures is deemed high enough so that the optimal quality level is when all the parts produced conform to the design specifications.

Example

The tolerance for the part is 12 (0.05". One-hundred per cent of the parts conform to these limits. Management feels that the cost of even incidental failure to conform is large enough to warrant more prevention and/or appraisal to reduce the number of defects to zero.

The concept

Not only should 100 per cent of the parts conform to specification but no deviation from the desired specification is allowed.

Example

The tolerance for the part is 12 (0.00". One-hundred per cent of the parts conform to these limits. Management feels that conforming to the specified limits is not enough – variability and deviations from the desired point must be maintained at zero or at least minimized.

Performance quality

The concept

The dissatisfaction level of the customer should be low enough at a point where the marginal estimated cost of prevention and appraisal is equal to the marginal cost of additional dissatisfaction.

Example

Customer surveys indicate that less than 5 per cent of the customers are dissatisfied with the colours on the TV manufactured by our firm. The management also feels that trying to satisfy more customers is not justified in terms of additional costs of prevention and appraisal.

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The concept
The marginal cost of failures is deemed high enough so that the optimal quality level is when all customers are very satisfied with the performance. The only dissatisfactions noticed are those customers who did not use the product properly.

Example
Customer surveys indicate that no customer who has used the product properly feels dissatisfied with the performance of the product.

The concept
The part must be insensitive to changes of uncontrollable parameters and must be able to withstand unspecified uses. Customers are very loyal.

Example
The parts are not only fully satisfying to the customers when used as per specifications but is also fully operational and provides high quality performance even when the customer uses it differently.

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(Dr. Kashi R. Balachandran is Professor of accounting and operations management at the Stern School of Business, New York University. He has published about 60 papers in numerous academic and professional journals. He has a PhD in operations research from the University of California at Berkeley and a certificate in management accounting. Bin Srinidhi has been Associate Professor of accounting, Faculty of Management, Rutgers University from 1990 and consultant with Cybernetica Consulting Inc. from 1995. He has a PhD from Columbia University. He has contributed to more than 20 publications, both academic and professional journals, covering quality management, cost management, accounting, management science and economics. His consulting experience is mainly in the area of cost and quality management with a strategic interface.)

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Strategic positioning and cost management along various quality dimensions

K.R. Balachandran and Bin Srinidhi

Keywords Operating systems, Performance, Policy, Quality, TQM

The traditional view of quality treats it as an economic good which can be developed by incurring costs. Proponents of total quality management have rejected the traditional view and stress the complementary nature of cost and quality. Reconciles these two views as different manifestations of the same underlying phenomenon within the same strategic framework. This requires precise definitions of quality concepts such as conformance and performance quality. The organization first examines its current position within this framework. The definitions of quality help sharpen the formulation of strategic objectives and the framework helps in mapping out a policy for moving the firm from the current position to the desired position. In addition, also determines the operating systems of quality management by how quality is defined in the organization. In conjunction with the strategic direction, the operational management procedures facilitate the process of cost management.

An investigation of the willingness of UK certificated firms to recommend ISO 9000

Francis Buttle

Keywords Certification, Improvement, ISO 9000, Organization, United Kingdom

Presents survey results which are derived from the most comprehensive investigation ever undertaken of UK companies certificated to ISO 9000. Reports an analysis of the willingness of certificated companies to recommend the standard to other, similar companies. States that the 4,250 certificated organizations mail surveyed, 1,220 (28.7 per cent) responded. Indicates that the companies most willing to recommend ISO 9000 were those most satisfied with the organizational impacts of the standard and these were of three major kinds: profitability impacts, process improvements and marketing benefits. Reports that companies also willing to recommend were those whose expectations had been met, and those who believed the standard to be cost-effective. Proposes that these results should help deflect criticism about the perceived value of the standard, and motivate companies to pursue certification.

US health-care revolution: cost and quality challenges

June H. Larrabee

Keywords Consumerism, Costs, Health care, Quality, USA

Discusses challenges facing the US health-care system now that prepaid or capitated health plans are gaining market share. Investigates how this affects providers, payers and policy makers and the concerns for the maintenance of a quality system. Concludes that the current changes in the US health-care system are driven by the changing role of the consumer, concerns for quality and efforts to contain costs. Maintains that further research is needed to provide better guidelines to help these challenges to be met.

Global excellence in management systems: a Diamond Offshore Drilling case

Vipul K. Gupta and Denis Graham

Keywords Business-to-business marketing, Case studies, Environment, Oil industry, Quality management, Safety

How do managers, in their role as decision makers, design and implement systems for management of quality? Proposes that there is no one, definitive answer to this question, given various industrial environments and their operating constraints, diverse market conditions and numerous management philosophies. Attempts to address quality management issues in the business-to-business industrial service industry by presenting a case study on the quality management approach taken by Diamond

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