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Quality costing for total quality management

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Abstract

Many organisations' competitiveness is seriously damaged by the quality related costs of correcting errors, redoing things, apologising to customers, etc. An extensive survey of the published literature in this field shows that the median quality cost expressed as a percentage of sales turnover is 18%. A survey of small firms in the North of England showed that only a minority of firms systematically monitor quality costs and that quality costs are frequently underestimated.

Total Quality Management (TQM) focuses on processes and process improvement. The widely recognised P–A–F Quality Cost Model does not address processes and is of limited use in a TQM programme. Newer techniques such as Process Cost Modelling use a process approach and contribute to quality improvement itself.

Models should also integrate quality costs and the wider range of benefits of quality improvement. A simple Cost-Benefit Model is developed to illustrate this aspect.

1. Introduction

An organisations competitiveness is seriously eroded by the costs of correcting errors, redoing things, apologising to customers etc. The quality related cost of these nonproductive activities has been estimated to be as high as 20% of sales revenue across a wide range of industries [1].

Total Quality Management (TQM) focuses on process improvement and the elimination of all forms of waste. A realistic estimation of quality costs is an essential element of any TQM initiative. However, in spite of the large volume of literature on the importance and principles of quality costing, only a minority of organisations use formal quality costing methods. This is highlighted in the studies of Duncalf and Dale [2], and Dale and Plunkett [3]. Monk [4] asserts that measuring quality costs is essential if quality professionals and general management are to communicate with each other.

Quality costing serves the following purposes:

- As a tool for gaining senior management commitment.
- As a means of preparing a case for a Total Quality Management initiative.
- As a tool for highlighting areas for improvement.
- As a means of providing estimates of the potential benefits to be gained through quality improvement.

2. A review of quality cost models

2.1. Feigenbaum's P–A–F Model

There appears to be only one widely recognised scheme for categorising quality costs. After a review of the literature, Plunkett and Dale [5] state that the "Feigenbaum" classification is "almost universally" accepted.

Feigenbaum [6] built on the work of Masser [7] and identified three cost categories:

Prevention costs. The cost of any action taken to investigate, prevent or reduce the risk of nonconformity or defects.

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Appraisal costs. The cost of evaluating the achievement of quality requirements.

Failure costs. The costs of nonconformity both *internal* (discovered before delivery to the customer, including scrap, rework, re-inspection and redesign) and *external* (discovered after delivery to the customer, including warrantly costs and service calls).

Feigenbaum advocated that quality costs should be expressed as a ratio against sales turnover, production costs or the value of material used.

Typically Feigenbaum's costs are related. As appraisal costs rise, failure costs tend to fall. This is because more failures are discovered at an earlier stage. The cost of rectifying a mistake increases as the faulty items proceeds down the production process. In a manufacturing environment, it costs less to reject faulty material at the goods inward stage than it does to scrap a manufactured item that has had the faulty material incorporated into it. Figure 1, (after Dempsey [8]) shows how the cost of a fault in an component increases with each manufacturing operation.

However, as further investment is made in appraisal, the reductions in failure costs are likely to decrease. Inspection and other appraisal activities can never be 100% successful. Figure 2 (after Juran, [9]) shows how these two costs relate and

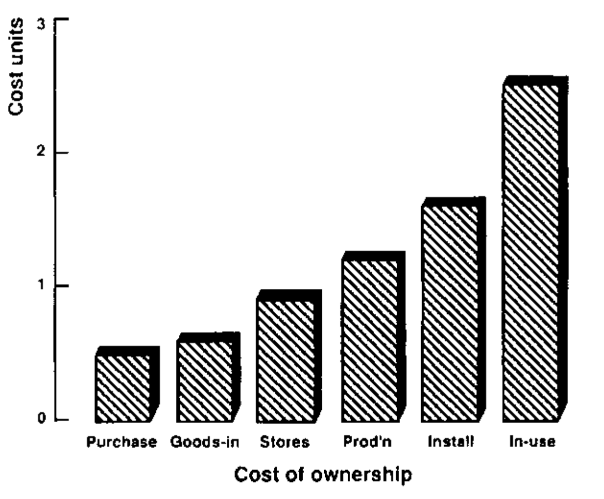

Fig. 1. The cost of rectifying a fault at successive stages of manufacture.

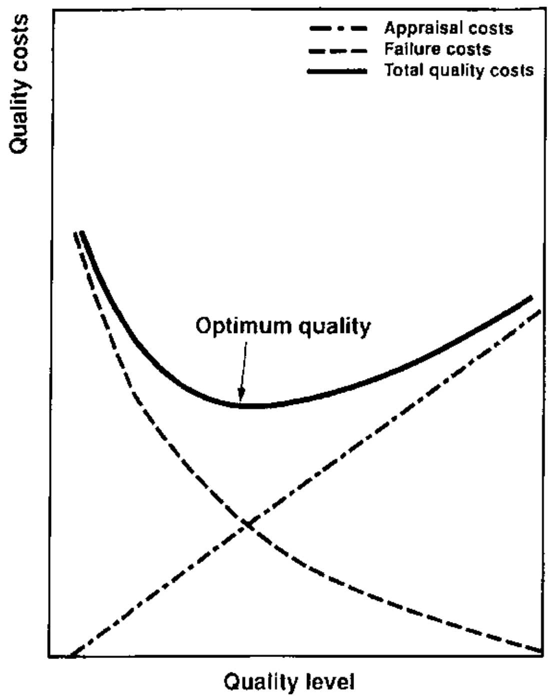

Fig. 2. The relationship between appraisal and failure costs.

reflects the traditional "quality control" view where quality depends upon inspection and rejection of nonconforming products. The illustration shows that for any given quality standard there is a trade-off between costs and product quality and there is an optimum point beyond which further expenditure on quality control produces less than proportionate increases in profit.

The TQM philosophy is that it is better to prevent the failures from ever occurring in the first place. Accordingly, as time and effort is invested in failure prevention activities, failure costs are reduced with no increase in appraisal costs. Thus investment in engineering reviews, plant capability studies and employee training can lead to significant reductions in quality costs. This is particularly important in activities such as the development of computer software where many faults result from inadequate review of client requirements. Boehm [10] has shown that the cost of fixing an error once a computer program has been released to a user is sixty times higher than the cost of fixing it at an initial design review.

Figure 3 shows how prevention reduces failure costs. However, there is still an optimum point beyond which further investment in prevention is unprofitable and the attainment of 100% quality or "zero defects" would require an infinite investment in prevention.

Schneiderman [11] argued that, in some circumstances, if enough effort is put into prevention, no defects at all would be produced, resulting in zero failure costs and obviating any need for appraisal. In these circumstances, the only optimum point is "zero-defects". He sites the success of some Japanese organisations in reducing failure costs to very small proportions by the total involvement of all employees in quality improvement as supporting his thesis.

Figure 4 shows Schneiderman's concept of the relationship between different quality costs.

Some organisations have committed themselves to the principle that zero defects can be achieved. At the Martin organisation in Florida, Crosby initiated a "zero defects" program to promote in each employee a desire to perform every task "right first time" [12]. This represented a determined effort to motivate employees and to reinforce pride in work and craftsmanship. In spite of its name, however, few departments were allocated immediate targets of zero defects although the aim of the program was for all departments to eventually reach such targets.

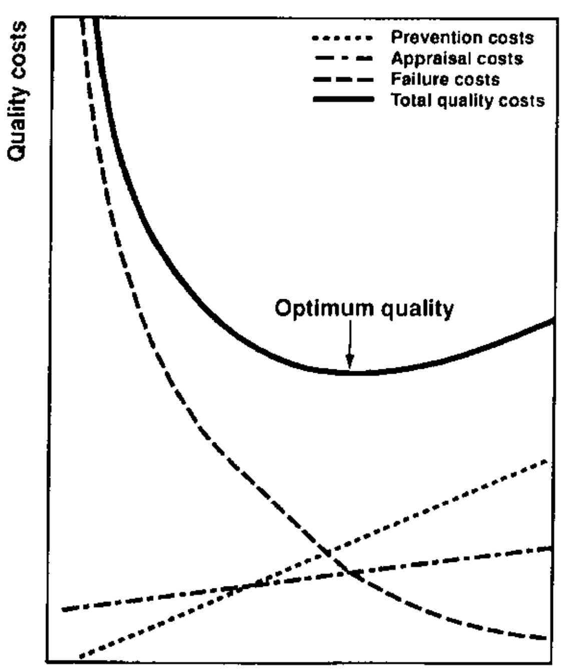

Fig. 3. The relationship between prevention, appraisal and failure costs.

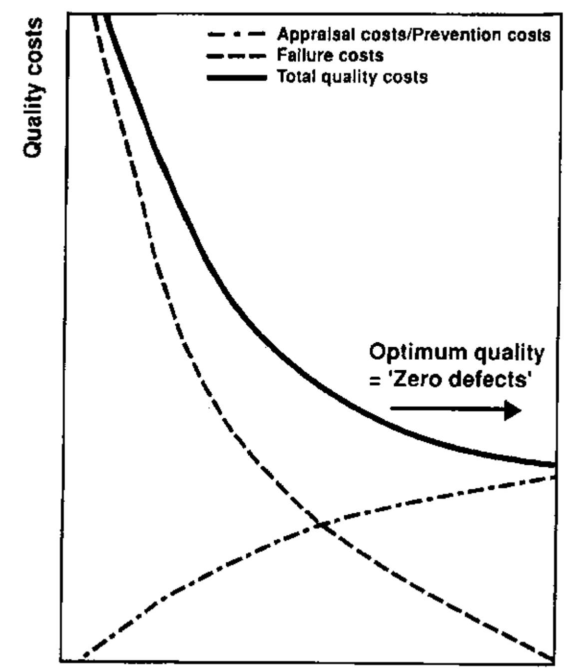

Fig. 4. The relationship between failure and appraisal/prevention costs in a zero defects programme.

Feigenbaum's prevention–appraisal–failure (P–A–F) scheme has been adopted by the British Standards Institute to form the basis of the British Standard for quality costs BS6143: Part 2: 1990 [13], and by the American Society for Quality Control, ASQC 1974 [14]. Major British companies who record quality costs, (such as GEC–Plessey Telecommunications, Ferranti, York International and STC) all use the P–A–F scheme.

2.2. *Limitations of the P–A–F model*

There appear to be a number of drawbacks to the P–A–F scheme. Prevention of problems is one of the prime functions of management and it will always be difficult to decide which activities represent "prevention of quality failures" and those which are just good management. Caplen [15] claims that there is no precise definition of quality costs and points out that "almost everything we do in a company has something to do with quality". He recognises, however, that it is usual to consider them under the P–A–F headings.

Rae [16] identifies a range of manufacturing and production engineering functions which are integral to ensuring product quality which would never be included in any schedule of quality costs. Studies of Japanese Industry, such as those of Newell and Radley [17] and Schonberger [18] show that high productivity and high quality are the result of thorough and professional production engineering aimed at simplicity. This is integral to their method of business management and could not be separated out as a separate "quality" activity.

Feigenbaum [6] was himself aware of the difficulties of obtaining the basic data for preparing quality cost statements. Even when suitable data is available it may have to be adjusted. For example, many companies record the costs of warranty work. To be useful, however, such data should be "offset" to allow for the period in which the fault was generated rather than when it was discovered.

The logic of Total Quality Management implies that all quality costs should be recorded in a totally comprehensive program. However, Plunkett and Dale [5] claim that this rarely happens and that most schemes are aimed at particular quality improvement projects. Part of the reason may be the difficulty of gaining the cooperation of accountants. Oakland [19] points out that collecting quality costs will cut across the conventional accounting rules of most organisations. Cox [20] suggested that usually accounts departments will lack the time and resources that a major new accounting activity is likely to require. Groocock [21] describes implementing a comprehensive quality costing system as "a task of daunting difficulty".

Another problem is that there is no agreement on how accurately costs should be monitored. Sullivan [22] argues that "formal quality costs must be able to stand up to scrutiny by management and accounting" and hence must be totally accurate. In contrast, Dane [23] argues that while a quality costing system must include "total costs" so that a balance can be gained, high accuracy is not required. Carson [24] suggests that an accuracy of $\pm 20\%$ will suffice. However Plunkett and Dale [25] point out that the necessary degree of accuracy will depend upon the exact purpose for which the costs are being collected.

A further serious criticism of the P–A–F model is that firms which have achieved notable reductions in quality costs do not always seem to have greatly increased their expenditure on prevention. For example GEC–Plessey Telecommunications have reduced their costs of quality in four years from 25% to 14%. However, the company's Director of Quality reports that the percentage of these costs taken up by prevention activities appear to be about the same [26].

Furthermore, it is sometimes impossible to uniquely categorise a cost into the three categories. Design reviews may be considered a prevention cost, an appraisal cost or a failure cost depending upon how and where they are used in the process [13].

Another serious criticism of the P–A–F model is that it focuses attention on cost reduction and ignores the positive contribution to sales volume and price that improved quality can provide. It is also worth noting that all of the successful applications of the P–A–F model would seem to be large companies. There appears to be no record of its successful use in small companies.

The conceptual approach to quality costing illustrated in Figs. 2–4 is also open to serious criticism. A firms position on the quality axis is impossible to determine as there will be many elements of quality in a typical product or service. Each element will have its own P–A–F structure. Furthermore, investment in prevention activities will result in an uncertain future stream of failure costs savings. Diagrams such as Figs. 2–4 fail to capture this dynamic aspect of investing in quality.

However, the most serious criticism of many P–A–F models (Figs. 2 and 3) is that it implies an acceptable quality level as a result of the trade off between prevention and appraisal costs and failure costs. This is completely incompatible with the never ending improvement philosophy of TQM. The key focus of TQM is on process improvement. A cost categorisation system such as the P–A–F scheme does not consider process costs and such schemes are therefore of limited use in a TQM programme.

3. Other approaches to quality costing

Juran [9] advocates a less theoretical categorisation of quality costs which recognise the importance of tangibles and intangibles:

Tangible factory costs. Measurable costs such as scrap, rework, additional inspection.

Tangible sales costs. Measurable costs such as cost of handling customer complaints and warranty costs.

Intangible costs. Costs that can only be estimated, such as loss of customer goodwill, delays caused by stoppages and rework and loss of morale amongst staff.

Juran's scheme looks at the "global" picture, rather than concentrating on individual projects or product lines. Unlike the P–A–F model it accepts that both appraisal and prevention costs are inevitable and are not worth including, thus overcoming one drawback of the P–A–F model. It recognises the importance of intangible elements, which in the long term are often of greater importance than cost reductions.

The greatest benefit of improved quality is often the increase in market share that results rather than simple quality cost reductions. The PIMS (Profit Impact of Marketing Strategy) studies show that higher perceived quality is usually linked with higher market share [27]. Henn's [28] survey of British firms that had received government help to install quality systems showed that in 41% of firms questioned, there had been a significant increase in the number of their customers following improvements to their QA systems.

Superior quality can be converted into premium prices. Feigenbaum [29] claims that companies who make quality a priority are likely to have, on average, a 5% price advantage over competitors. At a transactional level, Kotler [30] has described how Caterpillar's 24-hour worldwide parts service, described as "lunacy in narrow economic terms" [31], can be converted into a 20% price premium. Quality does seem to correlate with profit. In a survey of 2700 PIMS companies, the top 20% in terms of perceived quality had a return on investment of 32% whilst the bottom 20% had a return of only 12% [21].

Broh [32] argues that higher profits through increased market share are the principle benefits of the control of product quality and that these benefits can be measured. Whilst he uses the P–A–F scheme, he expands the "external failure" category of costs to include an estimate of the gross profit lost on future sales resulting from product failure.

Broh's approach is similar to the model of consumer complaint behaviour put forward by Kotler [30]. By building a simple mathematical model of an imaginary soft-drink factory, Broh is able to show that failure to control quality can destroy a company in quality conscious markets. The recent recall, at a cost of £90m, of 160 million bottles of Perrier mineral water shows how realist Broh's model is [33].

Juran's model of costs allows for the inclusion of intangible internal benefits such as reduced stock and fewer "lost opportunities". Modarress and Ansari [34] have advocated that the P–A–F model be expanded to accommodate such benefits. They claim that the Japanese success in "achieving high product quality at lower cost" results almost entirely from a better control of manufacturing by the use of JIT and SPC. JIT (Just-in-Time) manufacturing results in greatly reduced stockholdings. SPC (Statistical Process Control) ensures process consistency. They argue that these two areas add "extra dimensions to the Feigenbaum model" – identified as the "cost of inefficient resource utilisation" and the cost of "quality design".

JIT manufacture can be achieved only by

working closely with suppliers and ensuring very high levels of raw material quality. It also requires great flexibility in manufacturing, as provided by the "Kanban" system. However it can have tremendous benefits, not just in the costs of stockholding, but in terms of storage space requirements and overall flexibility [18].

Inefficient resource utilisation is a significant burden on business. The Quality manager of a computer software house in North-West England recently estimated that "we lose the opportunity each year of earning £120,000 by having to redirect our implementation staff onto solving problems at customer sites caused by software failure [35].

However, neither Feigenbaum's nor Juran's schemes of quality costs categorisation cope with what is perhaps the greatest waste of resource in any organisation: the amount of management time that is spent on "firefighting" – performing a task which only exists because somebody didn't do the original job right first time. This can represent between 20% and 95% of employees' time [36]. A major UK bank estimate that 49% of its employees time is wasted in this way [37]. The cost to the organisation of such waste is almost incalculable; it is not just the cost of salaries and overheads that is wasted, it is the cost of all the things that could have been done in the time so saved – new products designed, new customers gained, better management decisions made.

It is unfortunate that Quality Management Systems such as ISO9000 contain no requirement to monitor such costs. Comprehensive monitoring of Internal and External Failure costs would help to identify where the greatest savings could be made and would help to make quality assurance a strategic issue.

There appears to be a wide gap between the theory and practice of quality management within many firms. It may be that in modern manufacturing, the conventional accounting methods on which both Feigenbaum's P–A–F and Juran's schemes are based, are inappropriate in any case. According to White [38], with modern systems the recovery of overhead is often an arbitrary and meaningless exercise. The conventional cost accounting approach is "distorting" and may hinder quality cost programmes by the arbitrary treatment of overhead costs. Successful companies like Hewlett Packard eschew the traditional approach to costing and concentrate on the cost driver approach.

This approach is similar to that advocated by Lenane [39], who pointed out that the P–A–F model of quality costing shows only a portion of qualities total costs. It misses what he calls "the cost of unquality" which includes all the uncontrolled labour and material costs. He advocates an operation-by-operation costs system which high-lights the quality cost of each product line.

4. The process approach to quality costing

A total quality cost system should focus on processes rather than products or services. The process operating costs of producing goods or services to customers requirements are of prime importance. The process cost is the total cost of conformance (COC) and the cost of nonconformance (CONC) for a particular process. The cost of performance (COC) is the actual process cost of producing products or services to the required standards, first time and every time, by a given specified process. The cost or nonconformance (CONC) are the failure costs associated with a process not being operated to the required standard. This is a much simpler and arguably more relevant, categorisation than the P–A–F scheme. Both categories (COC, CONC) may be capable of improvement although the "improvement process" may be different for each category. The process approach has been adopted in a draft British Standard [40].

In meeting customers requirements (internal and external) we must address the issue of process design and the operation of the process to that design. Process design is essentially a COC issue and operating to design a CONC issue.

Process cost models can be developed for any process by flowcharting the process, identifying the key process steps and the parameters that are monitored in the process. The COC and/or CONC for each stage can be measured or esti-

TABLE 1

The stages in process cost modelling
Flowchart the process and identify the process owners
Process owners form the improvement team
Identify key process stages
Calculate or estimate quality costs (cost of conformance + cost of nonconformance) at each stage
Categorise costs into equipment, environment, materials, methods or human resource costs
Prioritise failure costs and select process stages for improvement through reduction in nonconformance costs
Review flowchart to identify the scope for reductions in the cost of conformance
Monitor conformance and nonconformance costs on a regular basis and review for further improvements

mated and key areas for process improvement identified. High nonconformance costs at any particular step in the process may indicate a requirement for further expenditure on failure prevention activities. An excessive cost of conformance may indicate the requirements for a process redesign.

Attempts to reduce the cost of conformance require a thorough process understanding. This is best achieved by flowcharting the existing process, drawing a second flow chart of what the improved process could or should be and comparing the two flow charts to highlight the source of problems or waste, and the improvements required.

Cost data used in the model may be actual costs or estimates where the accounting system is unable to provide the necessary information. The stages in a process cost study are shown in Table 1.

Process cost modelling is more than just a simple tool to measure the financial gap between the actual performance of a process and its potential performance. The emphasis on process must contribute to the quality improvement process itself.

5. Cost–benefit models

None of the models considered so far effectively integrate quality costs and the benefits of quality improvement. Furthermore, neither the P–A–F model or Process Cost Model take account of the fact that expenditure on improvement and prevention activities is a form of investment. Effective quality improvement results in a future stream of benefits in the form of reduced failure costs, lower appraisal costs, increased market share etc. This point can be illustrated by considering the various stages or a typical TQM programme.

An illustrate example, involving an expenditure of £272,000 over six years, is shown in Table 2. This programme is based on the authors experience of implementing TQM. A time-scale action plan is shown in Fig. 5. The programme starts with a Senior Management education and awareness programme aimed at gaining commitment to TQM. A Quality Cost Project is started very early on in the programme. Table 3 shows a financial model of how the possible savings resulting from the implementation of a TQM programme compare against the typical costs of implementation and review. The model illustrates the benefit for a small/medium sized company, (£10m turnover), of reducing its quality costs from 5% to 2.5% over a 5 year period. All monetary figures are expressed at year one values and turnover is assumed to show no real growth over the period. The reduction in the cost of nonconformance results in a saving of £250,000 per annum by year six. The reduction in the cost of nonconformance is assumed to be linear over the duration of the programme. Implementation and "maintenance" costs of the various initiatives in the TQM programme are set against this saving to give a net saving of £221,000.

Since the money spent in year one on the TQM programme could have been used for alternative

TABLE 2

TQM programme – An illustrative example

	Cost (£,000)
1. Education and awareness programme for senior management	4
2. Strategic planning for TQM	5
3. General management TQM programme	18
4. General TQM training and updating	20 plus 10p.a.
5. Quality cost project and review	15 plus 4p.a.
6. TQM systems project and audits	25 plus 15p.a.
7. TQM teamwork programme	25
8. SPC advisory project	25

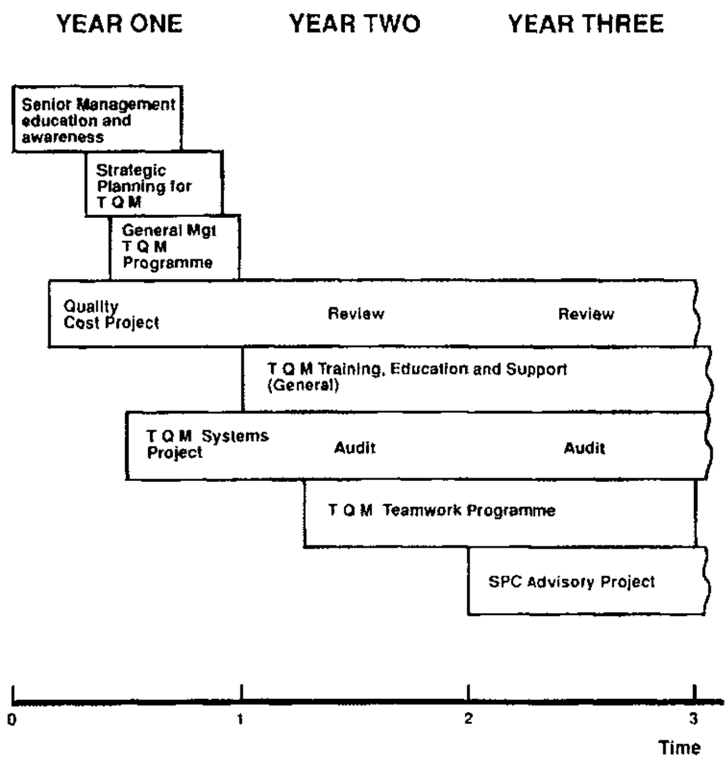

Fig. 5. Time scaled TQM action plan.

revenue generating activities, the net value of savings in years two to six should be discounted by an appropriate rate of return. This rate, identified as the Discount Rate, is assumed to be 15% in the model.

On this basis, the TQM programme would pay for itself during the fourth year.

Clearly, the specific figures used in the model will vary from firm to firm with some organisations achieving a higher or lower return on their investment in TQM.

The model makes no allowance for any extra sales that may be achieved by adopting a TQM approach. Moreover, some of the costs of developing and installing the TQM system are artificial since the effort is partly provided by existing

TABLE 3

Model of costs and internal benefits resulting from the implementation of a TQM programme

	Year 1	2	3	4	5	6
Savings						
Turnover (£,000)	10,000	10,000	10,000	10,000	10,000	10,000
% Identified nonconformance cost	5	4.5	4	3.5	3	2.5
Actual nonconformance cost	500	450	400	350	300	250
Total savings	0	50	100	150	200	250
Costs						
Senior management programme	9					
General management programme	18					
Quality cost project & review	15	4	4	4	4	4
General TQM training		20	10	10	10	10
TQM systems project and audits	25	15	15	15	15	15
TQM teamwork programme		17	8			
SPC advisory project			20	5		
Total costs	67	56	57	34	29	29
Net savings	(67)	(6)	43	116	171	221
Present value of net savings	(67)	(5.22)	32.51	76.27	97.78	109.88
Cumulative net present value	(67)	(72.22)	(39.71)	36.56	134.34	244.22

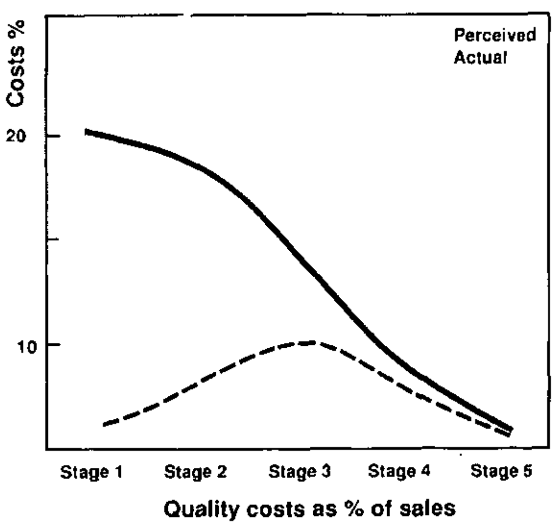

Fig. 6. The typical pattern of perceived and actual quality costs.

managers. However, it does demonstrate that, whilst in the short-term installing and maintaining a TQM system can be costly, in the long-term it is likely to pay off substantially.

The development of realistic cost-benefit models is essential for the effective global monitoring of TQM programmes.

6. The empirical evidence

Many writers argue that a comprehensive understanding of quality costs is the key to effective quality management. Crosby, for example, calls the measurement of such costs one of the "absolutes" of quality management [41]. He argues that such costs can and should be quantified and that the potential for saving in these areas can be as high as 20% of sales turnover. He claims that firms rarely have any idea how much profit they are losing through poor quality. Only as they initiate quality improvement programs does the true extent of their quality costs become apparent.

Figure 6 shows the typical gap between an organisation's appreciation of its quality costs and the actual costs during the various stages of a TQM programme. In the early stages of the programme there is a wide gap and organisations have a very poor appreciation of their quality costs. In later stages, the organisation's under-

TABLE 4

Examples of costs of quality in the UK

Organisation	Quality costs	Source
Machine tool manuf's (Bridgeport)	4%	Dale & Plunkett, 1988
Battery manufacturer (Chloride)	6%	DTI, 1987
Television factory	6%	Groocock, 1974
Motor parts (Garrett automotive)	6%	Dale & Plunkett, 1989
Aerospace (Rolls-Royce, Derby)	7%[a]	Rolls-Royce, 1987
Office equipment manuf (Rank Xerox)	9%[b]	Holmes, 1989
Aerospace (Brit. Aerospace, Lostock)	11%[b]	Dale & Plunkett, 1989
Metal processing (West Yorkshire)	12%	Parker, 1989
Electronics (Ferranti, Edinburgh)	12%[c]	Whitehall, 1986
Paint manufacturer (Crown)	13%[c]	Dale & Plunkett, 1989
Air conditioning (York Int.)	13%	Booth, 1989
Electronics (Cossor, Harlow)	18%	Chase, 1988
Electronics (Plessey, Oldham)	18%	Gibson, 1989
Textiles (Courtaulds)	20%	Dale & Plunkett, 1989
Chemicals (Grace Dearborn)	20%	Dale & Plunkett, 1989
Plastics printing (John McGavigan)	22%	Dale & Plunkett, 1989
Computer equipment (Hewlett-Packard)	22%	Bareman, 1985
Telecommunications (GPT, Liverpool)	25%	Casbourne, 1989
Bank (National Westminster)	25%[e]	Dale & Plunkett, 1989
Provision of building services	25%[d]	HVCA, 1977
Technical workshop (Brit Airways)	49%[d]	Dale & Plunkett, 1989

All quality costs expressed as a percentage of sales value except where noted otherwise
[a]Expressed as percentage of operating costs
[b]Expressed as percentage of costs of production
[c]Expressed as percentage of raw material usage costs
[d]Expressed as percentage of time spent
[e]Expressed as percentage of total cost

TABLE 5

Examples of costs of quality in the USA

Organisation	Quality costs	Source
Aircraft (Fairchild-Saab)	6.1%[f]	Campanella and Corcoran, 1983
Defence equipment (TRW Corp)	8%	Groocock, 1986
Floor polishing equip't (Tennant)	17%	Peters, 1988
Engineering organisation (FMC)	18%	Schrader, 1986
Manufacturing (Rogers Co)	19%[f]	Kenworthy, 1986
Glassware (Corning)	20–30%	Houghton, 1979
Communications company ($14m t/o)	29%	Crosby, 1979

[f]Expressed as percentage of manufacturing cost.

standing and awareness of quality costs is greater and the gap narrows.

A practical example of this awareness development is given by Casbourne [26]. GEC–Plessey Telecommunications initially estimated its cost of quality as 10% of turnover. Further investigation, however, revealed that the true figure was 25% of turnover. A quality improvement programme subsequently reduced this to 14% of turnover.

An extensive review by the authors of the published literature confirms that quality costs have a serious impact on an organisations profitability. In the UK and USA, quality costs have found to be in the range of 4% to almost 25% of sales turnover with a median value of 18%. The results of this review are shown in Tables 4 and 5. Quality costs can sometimes be put in a more appropriate context if they are calculated against a different base. For example, Dale and Plunkett [37] estimated quality costs as high as 41% of the time spent on a job for one specific example.

If approximately 20% of the cost of sales is wasted in quality related costs such as scrap, reworking, correcting errors, measuring, inspection and customer returns, the total cost to an economy must be enormous. For manufacturing industry in the UK, this cost was estimated to be in the region of £6bn in 1985 [1].

7. Quality costs survey in small firms

In order to find out the actual situation with respect to smaller firms in the UK, a survey was recently undertaken of twenty quality-oriented firms in the North of England (West Yorkshire). All the firms had achieved ISO9000/BS5750 certification. Whilst ISO9000/BS5750 contains no requirement to monitor quality costs, it was felt that certificated firms were the most likely ones to do so. The firms ranged in size from 2 to 200 employees, with a mean size of 57 [42].

The standard industrial classifications (SICs) of the firms in the sample was heavily weighted to engineering in general (with 65% in SIC 3*xxx*) and machinery manufacture in particular (35% in SIC 32*xx*). This partly reflects the type of industry to be found in West Yorkshire.

This spread is rather different from the overall ISO9000/BS5750 population as represented by BSI registrations [43]. However, it appears to be representative of certificated companies in West Yorkshire and there seems to be no reason to believe that the conclusions obtained from the survey are in any way unrepresentative of small and medium sized companies in general.

The survey revealed that only seven (35%) of the sample made any attempt to monitor quality costs. Only "failure" or "tangible factory" costs were recorded and all figures given appeared to involve an element of estimation. Estimates ranged from 0.8% to 3% of turnover with an mean of 1.87% of turnover.

Six companies estimated that such costs had fallen, in one case from 6.5% to 1.75% of turnover. One firm claimed that failure costs had increased from 0.5% to 0.8% of turnover since gaining certification. This had been caused by the adoption of tighter specifications, resulting in more internal rejections.

In spite of the volume of literature on the subject of quality costs, few of the firms surveyed made any attempt to monitor such costs and none used the Feigenbaum P–A–F model. It would appear that most of those surveyed regard prevention of waste and mistakes as a fundamental task of management, which could not be separately costed. Moreover, appraisal costs were usually regarded as an integral part of production overheads. This reinforces the view that P–A–F model is inappropriate to the needs of small and medium-sized firms.

The estimated costs of quality given by the firms is low when compared with the figures given in Table 4. The estimated costs exclude any element of prevention or appraisal costs and probably do not include all failure costs. It is likely that the true costs of inadequate quality are significantly greater – e.g. at least 5%. This would be consistent with Crosby's [41] claims that in the early stages of quality improvement programs firms substantially underestimate their quality costs.

The average turnover of the firms that were able to give estimates of quality costs is £2.69m. If the costs of inadequate quality are 5%, they must total £134,500 per annum. (Even if the costs are only 1.87% of turnover, they must total £50,000 per annum.) The experience of GEC–Plessey Telecommunications and the comments of Groocock [21] would suggest that effective quality improvement programmes can cut these costs in half over a period of five years.

8. Conclusions

Quality costing is an essential tool in any TQM programme. A quality cost survey should provide conclusive evidence for Senior Management of the need for a TQM approach. Furthermore, a quality cost survey will highlight improvement opportunities and provide estimates of possible benefits.

The P–A–F model is the only recognised international standard for quality costs [13,14]. However, the P–A–F model is mainly a cost categorisation scheme and it has serious limitations. A TQM programme requires a process approach and the P–A–F model generally fails in this area.

Recent developments in the field of quality costing include Process Cost Models. These focus on key processes within the organisation and attempt to quantify the cost of conformance and the cost of nonconformance. This approach is a driving force to process improvement in itself and is totally compatible with a TQM approach.

There is a clear need to develop models that effectively integrate the costs and benefits of TQM in a dynamic manner. Investment in TQM results in a future stream of benefits. A simple financial model illustrates how this investment in quality can result in a substantial future benefit. This type of model requires further development to incorporate a more realistic assessment of the range of benefits resulting from a TQM programme.

Many of the points raised in this paper are the subject of further detailed research work being carried out at the European Centre for Total Quality Management at Bradford.

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