SECTION 8
QUALITY AND COSTS

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INTRODUCTION

This section discusses how quality has an impact on the costs of goods and services in an organization. Section 7, Quality and Income, addresses the issue of quality and sales revenue. Thus, the two sections provide a framework of how quality is related to the total financial picture of an organization.

We identify and measure the costs associated with poor quality for three reasons: to quantify the size of the quality problem to help justify an improvement effort, to guide the development of that effort, and to track progress in improvement activities. Among the concepts and methodologies covered are traditional categories of quality costs, a broadened concept of categories including lost revenue and process capability costs, activity-based costing, data collection methods, return on quality, presentation of findings, gaining approval for an improvement effort, using cost data to support continuous improvement, optimum quality level, and reporting cost data. The underlying theme in the section is the use of quality-related costs to support a quality improvement effort rather than as a system of reporting quality costs.

We will follow the convention of using the term “product” to denote goods or services.

EVOLUTION OF QUALITY AND COSTS

During the 1950s there evolved numerous quality-oriented staff departments. The heads of these new departments were faced with "selling" their activities to the company managers. Because the main language of those managers was money, the concept of studying quality-related costs provided the vocabulary to communicate between the quality staff departments and the company managers.

Over the decades, as the staff quality specialists extended their studies, some surprises emerged:

1. The quality-related costs were much larger than had been shown in the accounting reports. For most companies, these costs ran in the range of 10 to 30 percent of sales or 25 to 40 percent of operating expenses. Some of these costs were visible, some of them were hidden.
2. The quality costs were not simply the result of factory operation, the support operations were also major contributors.
3. The bulk of the costs were the result of poor quality. Such costs had been buried in the standards, but they were in fact avoidable.
4. While these quality costs were avoidable, there was no clear responsibility for action to reduce them, neither was there any structured approach for doing so.

Quality specialists used the data to help justify quality improvement proposals and to track the cost data over time.

Those early decades of experience led to some useful lessons learned.

Lessons Learned. These lessons, discussed below, can help us to formulate objectives for tracking and analyzing the impact of quality on costs.

The Language of Money Is Essential. Money is the basic language of upper management. Despite the prevalence of estimates, the figures provide upper managers with information showing the overall size of the quality costs, their prevalence in areas beyond manufacture, and the major areas for potential improvement.

Without the quality cost figures, the communication of such information to upper managers is slower and less effective.

The Meaning of "Quality Costs." The term "quality costs" has different meanings to different people. Some equate "quality costs" with the costs of poor quality (mainly the costs of finding and correcting defective work); others equate the term with the costs to attain quality; still others use the term to mean the costs of running the Quality department. In this handbook, the term "quality costs" means the cost of poor quality.

Quality Cost Measurement and Publication Does Not Solve Quality Problems. Some organizations evaluate the cost of poor quality and publish it in the form of a scoreboard in the belief that publication alone will stimulate the responsible managers to take action to reduce the costs. These efforts have failed. The realities are that publication alone is not enough. It makes no provision to identify projects, establish clear responsibilities, provide resources to diagnose and remove causes of problems, or take other essential steps. New organization machinery is needed to attack and reduce the high costs of poor quality (see, generally, Section 5, The Quality Improvement Process).

Scoreboards, if properly designed, can be a healthy stimulus to competition among departments, plants, and divisions. To work effectively, the scoreboard must be supplemented by a structured improvement program. In addition, scoreboards must be designed to take into account inherent differences in operations among various organizational units. Otherwise, comparisons made will become a source of friction.

Scope of Quality Costs Is Too Limited. Traditionally, the measurement of quality cost focuses on the cost of nonconformities, i.e., defects in the goods or services delivered to external and internal customers. These are often called external and internal failure costs. An important cost that is not measured is lost sales due to poor quality (this is called a "hidden cost" because it is not easily measured). Another omitted cost is the extra cost in processes that were producing conforming output but which are inefficient. These inefficiencies are due to excess product or process variability (even though within specification limits) or inefficiencies due to redundant or non-value-added process steps.

Traditional Categories of Quality Costs Have Had a Remarkable Longevity. About 1945, a pioneering effort proposed that quality-related costs be assigned to one of three categories: failure costs, appraisal costs, and prevention costs. The pioneers emphasized that these categories were not the only way to organize quality costs; the important point was to obtain a credible estimate of the total quality cost. But many practitioners found the categories useful and even found ingenious ways to adapt the categories to special applications such as engineering design.

The experience that led to these lessons learned also included some changes in the quality movement:

1. An explosion in the acceptance of the concept of continuous improvement in all sectors—profit, nonprofit, and public.
2. Progress in understanding and in quantifying the impact of quality on sales revenue.
3. Emphasis on examining cross-functional processes to reduce errors and cycle time and improve process capability to increase customer satisfaction. These analyses confirm the benefits of (*a*) diagnosis of causes to reduce errors and (*b*) process analysis to identify redundant work steps and other forms of non-value-added activities.

From the lessons learned and the changes in the quality movement, we can identify some objectives for evaluating quality and costs.

Objectives of Evaluation. The primary objectives are

1. Quantify the size of the quality problem in language that will have an impact on upper management. The language of money improves communication between middle managers and upper managers. Some managers say: "We don't need to spend time to translate the defects into dollars. We realize that quality is important, and we already know what the major problems are." Typically when the study is made, these managers are surprised by two results. First, the quality costs turn out to be much higher than had been realized. In many industries they are in excess of 20 percent of sales. Second, while the distribution of the quality costs confirms some of the known problem areas, it also reveals other problem areas that had not previously been recognized.

2. Identify major opportunities for reduction in cost of poor quality throughout all activities in an organization. Costs of poor quality do not exist as a homogeneous mass. Instead, they occur in specific segments, each traceable to some specific cause. These segments are unequal in size, and a relative few of the segments account for the bulk of the costs. A major byproduct of evaluation of costs of poor quality is identification of these vital few segments. This results in setting priorities to assure the effective use of resources. We need to collect data on the cost of poor quality, analyze the data, and plan an improvement strategy that attacks chunks of the glacier rather than ice chips.

3. Identify opportunities for reducing customer dissatisfaction and associated threats to sales revenues. Some costs of poor quality are the result of customer dissatisfaction with the goods or service provided. This dissatisfaction results in a loss of current customers—"customer defections"—and an inability to attract new customers (for elaboration see Section 18 under Linking Customer Satisfaction Results to Customer Loyalty and to Processes). Addressing the areas of dissatisfaction helps to improve retention of current customers and create new customers.

4. Provide a means of measuring the result of quality improvement activities instituted to achieve the opportunities in 2 and 3 above. Measuring progress helps to keep a focus on improvement and also spotlights conditions that require removal of obstacles to improvements.

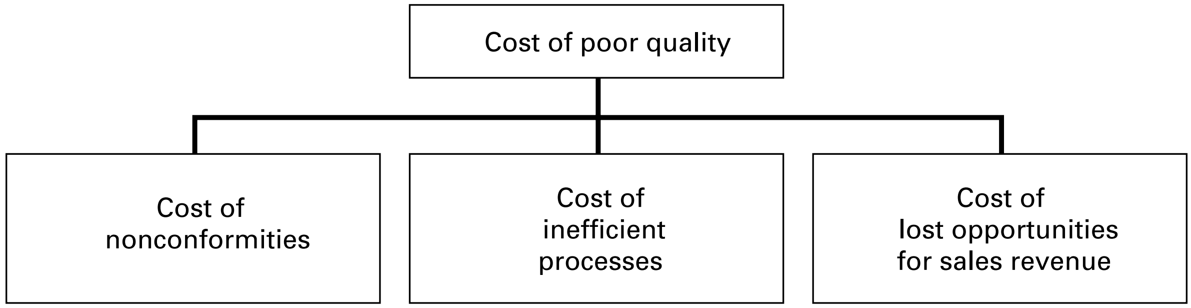

FIGURE 8.1 Components of the cost of poor quality.

5. Align quality goals with organization goals. Measuring the cost of poor quality is one of four key inputs for assessing the current status of quality (the others are market standing on quality relative to competition, the organization quality culture, and the activities composing the quality system). Knowing the cost of poor quality (and the other elements) leads to the development of a strategic quality plan consistent with overall organization goals.

Collectively, these objectives strive to increase the value of product and process output and enhance customer satisfaction. This section uses the framework shown in Figure 8.1. Note that this framework extends the traditional concept of quality costs to reflect not only the costs of nonconformities but also process inefficiencies and the impact of quality on sales revenue. Sometimes, the term "economics of quality" is employed to describe the broader concept and differentiate it from the traditional concept of "quality cost."

We must emphasize the main objective in collecting this data, i.e., to energize and support quality improvement activities. This is summarized in Figure 8.2. The term "cost of quality" used in this figure includes the prevention, appraisal, and failure categories which are discussed below.

CATEGORIES OF QUALITY COSTS

Many companies summarize these costs into four categories. Some practitioners also call these categories the "cost of quality." These categories and examples of typical subcategories are discussed below.

Internal Failure Costs. These are costs of deficiencies discovered before delivery which are associated with the failure (nonconformities) to meet explicit requirements or implicit needs of external or internal customers. Also included are avoidable process losses and inefficiencies that occur even when requirements and needs are met. These are costs that would disappear if no deficiencies existed.

Failure to Meet Customer Requirements and Needs. Examples of subcategories are costs associated with:

Scrap: The labor, material, and (usually) overhead on defective product that cannot economically be repaired. The titles are numerous—scrap, spoilage, defectives, etc.

Rework: Correcting defectives in physical products or errors in service products.

Lost or missing information: Retrieving information that should have been supplied.

Failure analysis: Analyzing nonconforming goods or services to determine causes.

Scrap and rework—supplier: Scrap and rework due to nonconforming product received from suppliers. This also includes the costs to the buyer of resolving supplier quality problems.

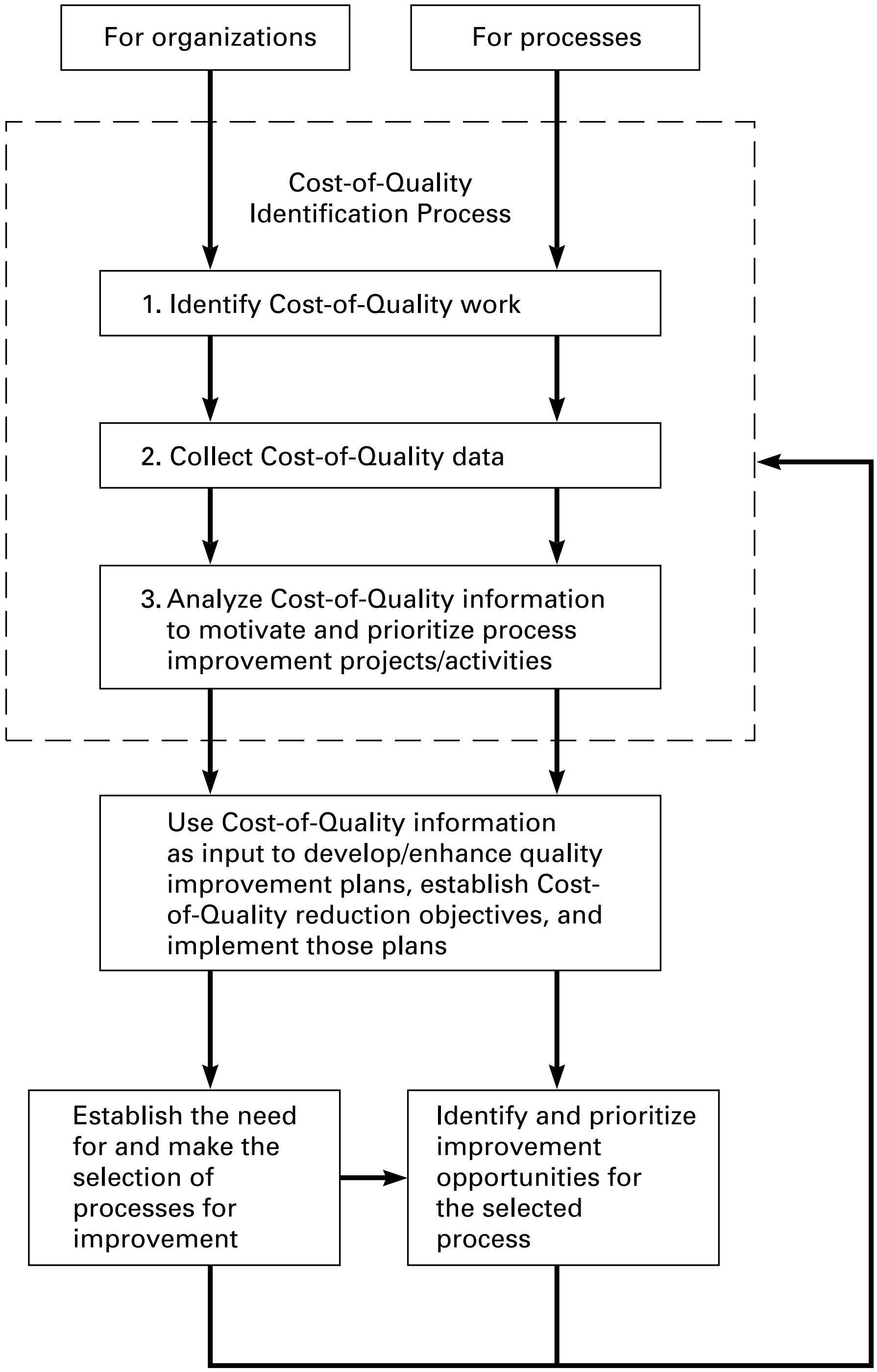

FIGURE 8.2 Cost of quality and quality improvement. (*AT&T 1990, p. 16.*)

One hundred percent sorting inspection: Finding defective units in product lots which contain unacceptably high levels of defectives.

Reinspection, retest: Reinspection and retest of products that have undergone rework or other revision.

Changing processes: Modifying manufacturing or service processes to correct deficiencies.

Redesign of hardware: Changing designs of hardware to correct deficiencies.

Redesign of software: Changing designs of software to correct deficiencies.

Scrapping of obsolete product: Disposing of products that have been superseded.

Scrap in support operations: Defective items in indirect operations.

Rework in internal support operations: Correcting defective items in indirect operations.

Downgrading: The difference between the normal selling price and the reduced price due to quality reasons.

Cost of Inefficient Processes. Examples of subcategories are

Variability of product characteristics: Losses that occur even with conforming product (e.g., overfill of packages due to variability of filling and measuring equipment).

Unplanned downtime of equipment: Loss of capacity of equipment due to failures.

Inventory shrinkage: Loss due to the difference between actual and recorded inventory amounts.

Variation of process characteristics from "best practice": Losses due to cycle time and costs of processes as compared to best practices in providing the same output. The best-practice process may be internal or external to the organization.

Non-value-added activities: Redundant operations, sorting inspections, and other non-value-added activities. A value-added activity increases the usefulness of a product to the customer; a non-value-added activity does not. (The concept is similar to the 1950s concept of value engineering and value analysis.)

For elaboration on variation and the cost of quality, see Reeve (1991). For a discussion of waste in "white collar" processes, see Quevedo (1991).

External Failure Costs. These are costs associated with deficiencies that are found after product is received by the customer. Also included are lost opportunities for sales revenue. These costs also would disappear if there were no deficiencies.

Failure to Meet Customer Requirements and Needs. Examples of subcategories are

Warranty charges: The costs involved in replacing or making repairs to products that are still within the warranty period.

Complaint adjustment: The costs of investigation and adjustment of justified complaints attributable to defective product or installation.

Returned material: The costs associated with receipt and replacement of defective product received from the field.

Allowances: The costs of concessions made to customers due to substandard products accepted by the customer as is or to conforming product that does not meet customer needs.

Penalties due to poor quality: This applies to goods or services delivered or to internal processes such as late payment of an invoice resulting in a lost discount for paying on time.

Rework on support operations: Correcting errors on billing and other external processes.

Revenue losses in support operations: An example is the failure to collect on receivables from some customers.

Lost Opportunities for Sales Revenue. Examples are

Customer defections: Profit margin on current revenue lost due to customers who switch for reasons of quality. An important example of this category is current contracts that are canceled due to quality.

New customers lost because of quality: Profit on potential customers lost because of poor quality.

New customers lost because of lack of capability to meet customer needs: Profit on potential revenue lost because of inadequate processes to meet customer needs.

Appraisal Costs. These are the costs incurred to determine the degree of conformance to quality requirements. Examples are

Incoming inspection and test: Determining the quality of purchased product, whether by inspection on receipt, by inspection at the source, or by surveillance.

In-process inspection and test: In-process evaluation of conformance to requirements.

Final inspection and test: Evaluation of conformance to requirements for product acceptance.

Document review: Examination of paperwork to be sent to customer.

Balancing: Examination of various accounts to assure internal consistency.

Product quality audits: Performing quality audits on in-process or finished products.

Maintaining accuracy of test equipment: Keeping measuring instruments and equipment in calibration.

Inspection and test materials and services: Materials and supplies in inspection and test work (e.g., x-ray film) and services (e.g., electric power) where significant.

Evaluation of stocks: Testing products in field storage or in stock to evaluate degradation.

In collecting appraisal costs, what is decisive is the kind of work done and not the department name (the work may be done by chemists in the laboratory, by sorters in Operations, by testers in Inspection, or by an external firm engaged for the purpose of testing). Also note that industries use a variety of terms for "appraisal," e.g., checking, balancing, reconciliation, review.

Prevention Costs. These are costs incurred to keep failure and appraisal costs to a minimum. Examples are

Quality planning: This includes the broad array of activities which collectively create the overall quality plan and the numerous specialized plans. It includes also the preparation of procedures needed to communicate these plans to all concerned.

New-products review: Reliability engineering and other quality-related activities associated with the launching of new design.

Process planning: Process capability studies, inspection planning, and other activities associated with the manufacturing and service processes.

Process control: In-process inspection and test to determine the status of the process (rather than for product acceptance).

Quality audits: Evaluating the execution of activities in the overall quality plan.

Supplier quality evaluation: Evaluating supplier quality activities prior to supplier selection, auditing the activities during the contract, and associated effort with suppliers.

Training: Preparing and conducting quality-related training programs. As in the case of appraisal costs, some of this work may be done by personnel who are not on the payroll of the Quality department. The decisive criterion is again the type of work, not the name of the department performing the work.

Note that prevention costs are costs of special planning, review, and analysis activities for quality. Prevention costs do *not* include basic activities such as product design, process design, process maintenance, and customer service.

The compilation of prevention costs is initially important because it highlights the small investment made in prevention activities and suggests the potential for an increase in prevention costs with the aim of reducing failure costs. The author has often observed that upper management immediately grasps this point and takes action to initiate an improvement effort. Experience also suggests, however, that continuing measurement of prevention costs can usually be excluded in order to (1) focus on the major opportunity, i.e., failure costs, and (2) avoid the time spent discussing what should be counted as prevention costs.

This part of the section focuses on the question "How much is it costing our organization by not doing a good job on quality?" Thus we will use the term "cost of poor quality." Most (but not all) of the total of the four categories is the cost of poor quality (clearly, prevention costs are not a cost of poor quality.) Strictly defined, the cost of poor quality is the sum of internal and external failure costs categories. But this assumes that those elements of appraisal costs—e.g., 100 percent sorting inspection or review—necessitated by inadequate processes are classified under internal failures. This emphasis on the cost of poor quality is related to a later focus in the section, i.e., quality improvement, rather than just quality cost measurement.

A useful reference on definitions, categories, and other aspects is Campanella (1999). For an exhaustive listing of elements within the four categories see Atkinson, Hamburg, and Ittner (1994). Winchell (1991) presents a method for defining quality cost terms directly in the language used by an organization.

Example from Manufacturing Sector. An example of a study for a tire manufacturer is shown in Table 8.1.

Some conclusions are typical for these studies:

1. The total of almost $900,000 per year is large.
2. Most (79.1 percent) of the total is concentrated in failure costs, specifically in "waste-scrap" and consumer adjustments.
3. Failure costs are about 5 times the appraisal costs. Failure costs must be attacked first.
4. A small amount (4.3 percent) is spent on prevention.

TABLE 8.1 Annual Quality Cost—Tire manufacturer

1. Cost of quality failures—losses		
a. Defective stock	$ 3,276	0.37
b. Repairs to product	73,229	8.31
c. Collect scrap	2,288	0.26
d. Waste-scrap	187,428	21.26
e. Consumer adjustments	408,200	46.31
f. Downgrading products	22,838	2.59
g. Customer ill will	Not counted	
h. Customer policy adjustment	Not counted	
Total	$697,259	79.10%
2. Cost of appraisal		
a. Incoming inspection	$ 23,655	2.68
b. Inspection 1	32,582	3.70
c. Inspection 2	25,200	2.86
d. Spot-check inspection	65,910	7.37
Total	$147,347	16.61%
3. Cost of prevention		
a. Local plant quality control engineering	$ 7,848	0.89
b. Corporate quality control engineering	30,000	3.40
Total	$ 37,848	4.29%
Grand total	$882,454	100.00%

5. Some consequences of poor quality could not be quantified, e.g., "customer ill will" and "customer policy adjustment." Here, the factors were listed as a reminder of their existence.

As a result of this study, management decided to increase the budget for prevention activities. Three engineers were assigned to identify and pursue specific quality improvement projects.

Example from Service Sector. Table 8.2 shows a monthly quality cost report for an installment loan process at one bank. Only those activities that fall into the four categories of quality cost are shown. The monthly cost of quality of about $13,000 for this *one* process is equivalent to about $160,000 per year for this bank. Table 8.2 quantifies loan costs throughout a typical consumer loan life cycle (including loan payoff). Note that the internal and external failure costs account for about half of total quality costs. These failure costs—which are preventable—are now tracked and managed for reduction or elimination so that they do not become unintentionally built into the operating structure. From the moment the customer contacts the bank with a problem, all costs related to resolving the problem are external failure costs. (Also note the significant amount of appraisal cost.)

These two examples illustrate studies at the plant level and the process level, but studies can be conducted at other levels, e.g., corporate, division, plant, department, process, product, component, or on a specific problem. Studies made at higher levels are typically infrequent, perhaps annual. Increasingly, studies are conducted as part of quality improvement activities on one process or one problem and then the frequency is guided by the needs of the improvement effort. For further discussion, see below under Using Cost of Poor Quality Concept to Support Quality Improvement.

The concept of cost of poor quality applies to a gamut of activities. For examples from manufacturing see Finnegan and Schottmiller (1990) and O'Neill (1988). In the service sector, useful discussions are provided as applied to hotels (Bohan and Horney 1991) and for educational testing (Wild and Kovacs

TABLE 8.2 Quality Cost Report—Installment Loans

Operation	Prevention	Appraisal	Internal failure	External failure
Making a loan:				
Run credit check	0	0	26	0
Process GL tickets and I/L input sheets	0	0	248	0
Review documents	0	3014	8	0
Make document corrections	0	0	1014	0
Follow up on titles, etc.	0	157	0	0
Review all output	0	2244	0	0
Correct rejects and incorrect output	0	0	426	0
Correct incomplete collateral report	0	0	0	78
Work with dealer on problems	0	0	0	2482
I/L system downtime	0	0	520	0
Time spent training on I/L	1366	0	0	0
Loan payment:				
Receive and process payments	0	261	784	0
Respond to inquiries when no coupon is presented with payments	0	0	784	0
Loan payoff:				
Process payoff and release document	0	0	13	0
Research payoff problems	0	0	13	0
Total cost of quality (COQ)	1366	5676	3836	2560
COQ as % of total quality cost	10.2	42.2	28.5	19.1
COQ as % of reported salary expense (25.6%)	2.6	10.8	7.3	4.9

Source: Adapted from Aubrey (1988).

1994). Applications have also been made to functional areas. For marketing, see Carr (1992) and Nickell (1985); for engineering see Schrader (1986); for "white collar" see Hou (1992) and Keaton et al. (1988). The Conference Board (1989) presents the results of a survey of 111 companies (manufacturing and service) on current practices in measuring quality costs.

Finalizing the Definitions. Although many organizations have found it useful to divide the overall cost into the categories of internal failure, external failure, appraisal, and prevention, the structure may not apply in all cases. Clearly, the practitioner should choose a structure that suits company need. In defining the cost of poor quality for a given organization, the following points should be kept in mind.

1. The definitions should be tailor-made for each organization. The usual approach is to review the literature and select those detailed categories which apply to the organization. The titles used should meet the needs of the organization, not the literature. This selected list is then discussed with the various functions to identify additional categories, refine the wording, and decide on broad groupings, if any, for the costs. The resulting definitions are "right" for the organization.

2. The key categories are the failure cost elements because these provide the major opportunity for reduction in costs and for removal of the causes of customer dissatisfaction. These costs should be attacked first. Appraisal costs are also an area for reduction, especially if the causes of the failures are identified and removed so as to reduce the need for appraisal.

3. Agreement should be reached on the categories of cost to include before any data are collected. Upper management should be a party to this agreement. Initially, summarized data on scrap and rework can gain management's attention and stimulate the need for a full study. Such summaries can be an impetus for management to become personally involved, for example, by calling and chairing the meetings to finalize the definition of the cost of poor quality. The quality specialist and the accountant both have key roles.

4. Certain costs routinely incurred may have been accepted as inevitable but are really part of the cost of poor quality. Examples are the costs of redesigning the product made necessary by deficiencies in fitness for use and the costs of changing the manufacturing process because of an inability to meet product specifications. If the original design and original manufacturing plans had been adequate, these costs would not have occurred. Typically, these costs have been accepted as normal operating costs, but should be viewed as opportunities for improvement and subsequent cost reduction.

5. As the detailed categories of the cost of poor quality are identified, some categories will be controversial. Much of the controversy centers around the point: "These are not quality-related costs but costs that are part of normal operating expenses and therefore should not be included." Examples are inclusion of full overhead in calculating scrap costs, preventive maintenance, and loss in morale.

In most companies, the cost of poor quality is a large sum, frequently larger than the company's profits. This is true even when the controversial categories are not included, so it is prudent to omit these categories and avoid the controversy in order to focus attention on the major areas of potential cost reduction. Some efforts to quantify quality costs have failed because of tenacious insistence by some specialists that certain controversial categories be included. A useful guide is to ask: "Suppose all defects disappeared. Would the cost in question also disappear?" A "yes" answer means that the cost is associated with quality problems and therefore should be included. A "no" answer means that the category should not be included in the cost of poor quality.

At the minimum, controversial categories should be separated out of the totals so that attention will be directed to the main issues, i.e., the failure costs.

Hidden Costs. The cost of poor quality may be understated because of costs which are difficult to estimate. The "hidden" costs occur in both manufacturing and service industries and include:

1. Potential lost sales (see above under External Failure Costs).
2. Costs of redesign of products due to poor quality.

3. Costs of changing processes due to inability to meet quality requirements for products.
4. Costs of software changes due to quality reasons.
5. Costs of downtime of equipment and systems including computer information systems.
6. Costs included in standards because history shows that a certain level of defects is inevitable and allowances should be included in standards:
   a. *Extra material purchased:* The purchasing buyer orders 6 percent more than the production quantity needed.
   b. *Allowances for scrap and rework during production:* History shows that 3 percent is "normal" and accountants have built this into the cost standards. One accountant said, "Our scrap cost is zero. The production departments are able to stay within the 3 percent that we have added in the standard cost and therefore the scrap cost is zero." Ah, for the make-believe "numbers game."
   c. *Allowances in time standards for scrap and rework:* One manufacturer allows 9.6 percent in the time standard for certain operations to cover scrap and rework.
   d. *Extra process equipment capacity:* One manufacturer plans for 5 percent unscheduled downtime of equipment and provides extra equipment to cover the downtime. In such cases, the alarm signals ring only when the standard value is exceeded. Even when operating within those standards, however, the costs should be a part of the cost of poor quality. They represent opportunities for improvement.
7. Extra indirect costs due to defects and errors. Examples are space charges and inventory charges.
8. Scrap and errors not reported. One example is scrap that is never reported because of fear of reprisals, or scrap that is charged to a general ledger account without an identification as scrap.
9. Extra process costs due to excessive product variability (even though within specification limits): For example, a process for filling packages with a dry soap mix meets requirements for label weight on the contents. The process aim, however, is set above label weight to account for variability in the filling process. See Cost of Inefficient Processes above under Internal Failure Costs.
10. Cost of errors made in support operations, e.g., order filling, shipping, customer service, billing.
11. Cost of poor quality within a supplier's company. Such costs are included in the purchase price.

These hidden costs can accumulate to a large amount—sometimes three or four times the reported failure cost. Where agreement can be reached to include some of these costs, and where credible data or estimates are available, then they should be included in the study. Otherwise, they should be left for future exploration.

Progress has been made in quantifying certain hidden costs, and therefore some of them have been included in the four categories discussed above. Obvious costs of poor quality are the tip of the iceberg.

Atkinson et al. (1991) trace the evolution of the cost of quality, present research results from four organizations (manufacturing and service), and explain how cost of quality data is applied in continuous improvement programs.

International Standards and Quality Costs. The issue of quality costs is addressed in ISO 9004-1 (1994), *Quality Management and Quality System Elements—Guidelines,* Section 6, "Financial Considerations of Quality Systems." This standard is advisory rather than mandatory. Three approaches to data collection and reporting are identified (but others are not excluded):

1. *Quality costing approach:* This is the failure, appraisal, and prevention approach described above.
2. *Process cost approach.* This approach collects data for a process rather than a product. All process costs are divided into cost of conformity and cost of nonconformity. The cost of conformity includes *all* costs incurred to meet stated and implied need of customers. Note that this is the cost incurred when a process is running without failure, i.e., material, labor, and overhead including prevention and process control activities. This cost includes process inefficiencies. The cost of nonconformity is the traditional cost of internal and external failures. The focus is to reduce both the cost of conformity and the cost of nonconformity.

3. *Quality loss approach:* This approach includes, but goes beyond, internal and external failure costs. Conceptually it tries to collect data on many of the "hidden" costs such as loss of sales revenue due to poor quality, process inefficiencies, and losses when a quality characteristic deviates from a target value even though it is within specification limits. Under this approach the costs can be estimated by using the Taguchi quality loss function.

For a comparison of these three approaches, see Schottmiller (1996). To provide further guidance, Technical Committee 176 of the International Organization for Standardization is developing a document, ISO/CD 10014, *Guideline for Managing the Economics of Quality.* This document will address both costs and customer satisfaction and will apply to "for profit" and "not for profit" organizations. Shepherd (1998) reviews the experiences with quality costs of over 50 organizations that successfully implemented ISO 9000.

MAKING THE INITIAL COST STUDY

A study of the cost of poor quality is logically made by the accountant, but the usual approach follows a different scenario. A quality manager learns about the quality cost concept and speaks with the accountant about making a study. The accountant responds that "the books are not kept that way." The accountant does provide numbers on scrap, rework, or certain other categories, but is not persuaded to define a complete list of categories and collect the data. The quality manager then follows one of two routes: (1) unilaterally prepares a definition of the categories and collects data or (2) presents to upper management the limited data provided by the accountant, and recommends that a full study be made using the resources of Accounting, Quality, and other functions. The second approach is more likely to achieve acceptance of the results of the study.

Sequence of Events. The following sequence applies to most organizations.

1. Review the literature on quality costs. Consult others in similar industries who have had experience with applying quality cost concepts.
2. Select one organizational unit of the company to serve as a pilot site. This unit may be one plant, one large department, one product line, etc.
3. Discuss the objectives of the study with the key people in the organization, particularly those in the accounting function. Two objectives are paramount: determine the size of the quality problem and identify specific projects for improvement.
4. Collect whatever cost data are conveniently available from the accounting system and use this information to gain management support to make a full cost study.
5. Make a proposal to management for a full study. The proposal should provide for a task force of all concerned parties to identify the work activities that contribute to the cost of poor quality. Work records, job descriptions, flowcharts, interviews, and brainstorming can be used to identify the activities.
6. Publish a draft of the categories defining the cost of poor quality. Secure comments and revise.
7. Finalize the definitions and secure management approval.
8. Secure agreement on responsibility for data collection and report preparation.
9. Collect and summarize the data. Ideally, this should be done by Accounting.
10. Present the cost results to management along with the results of a demonstration quality improvement project (if available). Request authorization to proceed with a broader company-wide program of measuring the costs and pursuing projects. See below under Gaining Approval for the Quality Improvement Program.

Clearly, the sequence must be tailored for each organization.

The costs associated with poor quality typically span a variety of departments (see Figure 8.3), and thus it is important to plan for this in data collection.

Data Collection. The initial study collects cost data by several approaches:

1. *Established accounts:* Examples are appraisal activities conducted by an Inspection department and warranty expenses to respond to customer problems.
2. *Analysis of ingredients of established accounts:* For example, suppose an account called "customer returns" reports the cost of all goods returned. Some of the goods are returned because they are defective. Costs associated with these are properly categorized as "cost of poor quality." Other goods may be returned because the customer is reducing inventory. To distinguish the quality costs from the others requires a study of the basic return documents.
3. *Basic accounting documents:* For example, some product inspection is done by Production department employees. By securing their names and the associated payroll data, we can quantify these quality costs.
4. *Estimates:* Input from knowledgeable personnel is clearly important. In addition, several approaches may be needed.
   - ***a.*** *Temporary records:* For example, some production workers spend part of their time repairing defective product. It may be feasible to arrange with their supervisor to create a temporary record to determine the repair time and thereby the repair cost. This cost can then be projected for the time period to be covered by the study.
   - ***b.*** *Work sampling:* Here, random observations of activities are taken and the percent of time spent in each of a number of predefined categories can then be estimated (see Esterby 1984). In one approach, employees are asked to record the observation as prevention, appraisal, failure, or first time work (AT&T 1990, p. 35).
   - ***c.*** *Allocation of total resources:* For example, in one of the engineering departments, some of the engineers are engaged part time in making product failure analyses. The department, however, makes no provision for charging engineering time to multiple accounts. Ask each engineer to make an estimate of time spent on product failure analysis by keeping a temporary activity log for several representative weeks. As the time spent is due to a product failure, the cost is categorized as a failure cost.
   - ***d.*** *Unit cost data:* Here, the cost of correcting one error is estimated and multiplied by the number of errors per year. Examples include billing errors and scrap. Note that the unit cost per error may consist of costs from several departments.
   - ***e.*** *Market research data:* Lost sales revenue due to poor quality is part of the cost of poor quality. Although this revenue is difficult to estimate, market research studies on customer satisfaction and loyalty can provide input data on dissatisfied customers and customer defections.

Cost-of-poor-quality activity	Location in organization				
	Dept. A	Dept. B	Dept. C	Dept. D	Etc.
Discover status of late order	•	•			
Correct erroneous bills	•		•		
Expedite installation of late shipment	•			•	
Troubleshoot failures on installation		•	•	•	
Perform warranty repairs	•		•	•	
Dispose of scrap		•			
Replace unacceptable installation	•		•	•	
Etc.					

FIGURE 8.3 Costs of poor quality across departments. (*Romagnole and Williams 1995.*)

> Calculations can then be made to estimate the lost revenue. Table 8.3 shows a sample case from the banking industry. Note that this approach starts with annual revenue and does not take into account the loss over the duration of years that the customer would have been loyal to the company. For a more comprehensive calculation, see Section 18 under Linking Customer Satisfaction Results to Customer Loyalty Analysis and to Processes. Also note that the calculations in Table 8.3 do not consider the portion of satisfied customers who will be wooed away by competition.

A special problem is whether all of the defective product has been reported. An approach to estimate the total amount of scrap is the input-output analysis. A manufacturer of molded plastic parts followed this approach:

1. Determine (from inventory records) the pounds of raw material placed in the manufacturing process.
2. Determine the pounds of finished goods shipped. If necessary, convert shipments from units to pounds.
3. Calculate the overall loss as step 1 minus step 2.
4. Make subtractions for work in process and finished goods inventory.

The result is the amount of raw material unaccounted for and presumably due to defective product (or other unknown reasons). A comparison of this result and the recorded amount of defectives provides a practical check on the recorded number of defectives.

Another special problem is the rare but large cost, e.g., a product liability cost. Such costs can be handled in two ways: (1) report the cost in a special category separating it from the total for the other categories or (2) calculate an expected cost by multiplying the probability of occurrence of the unlikely event by the cost if the event does occur.

A common mistake in data collection is the pursuit of great precision. This is not necessary—it is a waste of resources and time. We determine the cost of poor quality in order to justify and support quality improvement activities and identify key problem areas. For that purpose, a precision of ±20 percent is adequate in determining the cost of poor quality.

Briscoe and Gryna (1996) discuss the categories and data collection as applied to small business.

COST OF POOR QUALITY AND ACTIVITY-BASED COSTING

One of the issues in calculating the costs of poor quality is how to handle overhead costs. Three approaches are used in practice: include total overhead using direct labor or some other base, include

TABLE 8.3 Revenue Lost through Poor Quality

$10,000,000	Annual customer service revenue
1,000	Number of customers
× 25%	Percent dissatisfied
250	Number dissatisfied
× 75%	Percent of switchers (60–90% of dissatisfied)
188	Number of switchers
× $10,000	Average revenue per customer
$1,880,000	Revenue lost through poor quality

Source: The University of Tampa (1990).

variable overhead only (the usual approach), or do not include overhead at all. The allocation of overhead can, of course, have a significant impact on calculating the total cost of poor quality and also on determining the distribution of the total over the various departments. Activity-based costing (ABC) can help by providing a realistic allocation of overhead costs.

Traditionally, manufacturing overhead costs are allocated to functional departments and to products based on direct labor hours, direct labor dollars, or machine hours. This method works fine but only if the single base used (e.g., direct labor hours) accounts for most of the total operational costs, as has been true in the past. Times have changed.

During the past 20 years, many manufacturing and service firms have experienced significant changes in their cost structure and the way their products are made. Direct labor accounted for about 50 to 60 percent of the total cost of the product or service, with overhead constituting about 20 percent of the cost. As companies became more automated through robotics and other means, direct labor costs have declined to about 5 to 25 percent and overhead costs have increased to about 75 percent in the total cost mix of the product.

Activity-based costing (ABC) is an accounting method that aims to improve cost-effectiveness through a focus on key cost elements. In doing this, ABC allocates overhead based on the factors (activities) which cause overhead cost elements to be incurred. These causal factors—called cost drivers—are measurable activities that increase overhead costs. ABC refines the way product costs are determined by using computer technology to economically track overhead costs in smaller categories with many cost drivers. These cost drivers are analogous to an allocation base such as direct labor hours in traditional allocation of overhead. But instead of just one cost driver (e.g., direct labor hours) there are many cost drivers such as machine setups, purchase orders, shipments, maintenance requests, etc. For each cost driver, an overhead rate is determined by dividing total costs for the driver (e.g., total cost for all machine setups) by the number of driver events (e.g., number of setups). The results might be for example, $90 per machine setup, $40 per purchase order, $120 per shipment, $80 per maintenance request. These overhead rates can then be applied to specific products, thus recognizing that every product or service does not utilize every component of overhead at exactly the same intensity, or in some cases, may not even use a given component at all. This more precise allocation of overhead can change the total cost of poor quality and the distribution over departments, thus influencing the priorities for improvement efforts.

Activity-based costing is more than an exercise in allocating overhead. This broader viewpoint of "activity-based cost management" emphasizes improvement in terms of cost reduction to be applied where it is most needed.

A basic accounting text that explains both activity-based costing and quality costs is Garrison and Noreen (l994). Other references relating activity-based costing and quality costs are Dawes and Siff (1993), Hester (1993), and Krause and Gryna (1995).

RETURN ON QUALITY

Improvement requires an investment of resources, and the investment must be justified by the blossoming benefits of improvement. The long-term effect of applying the cost of poor quality concept is shown in Figure 8.4. We will call the comparison of benefits to investment the "return on quality" (ROQ). Thus ROQ is really a return of investment (ROI) in the same sense as other investments such as equipment or an advertising program.

Using the expanded scope of cost of poor quality (see above under Categories of Quality Costs), the benefits of an improvement effort involve both reductions in cost and increases in sales revenue.

Some of the issues involved in estimating the benefits are

Reduced cost of errors: Expected savings, of course, must be based on specific plans for improvement. Often, such plans have a goal of cutting these costs by 50 percent within 5 years, but such a potential benefit should not be assumed unless the problem areas for improvement have been explicitly identified and an action plan with resources has been developed. In estimating present costs, don't inflate the present costs by including debatable or borderline items.

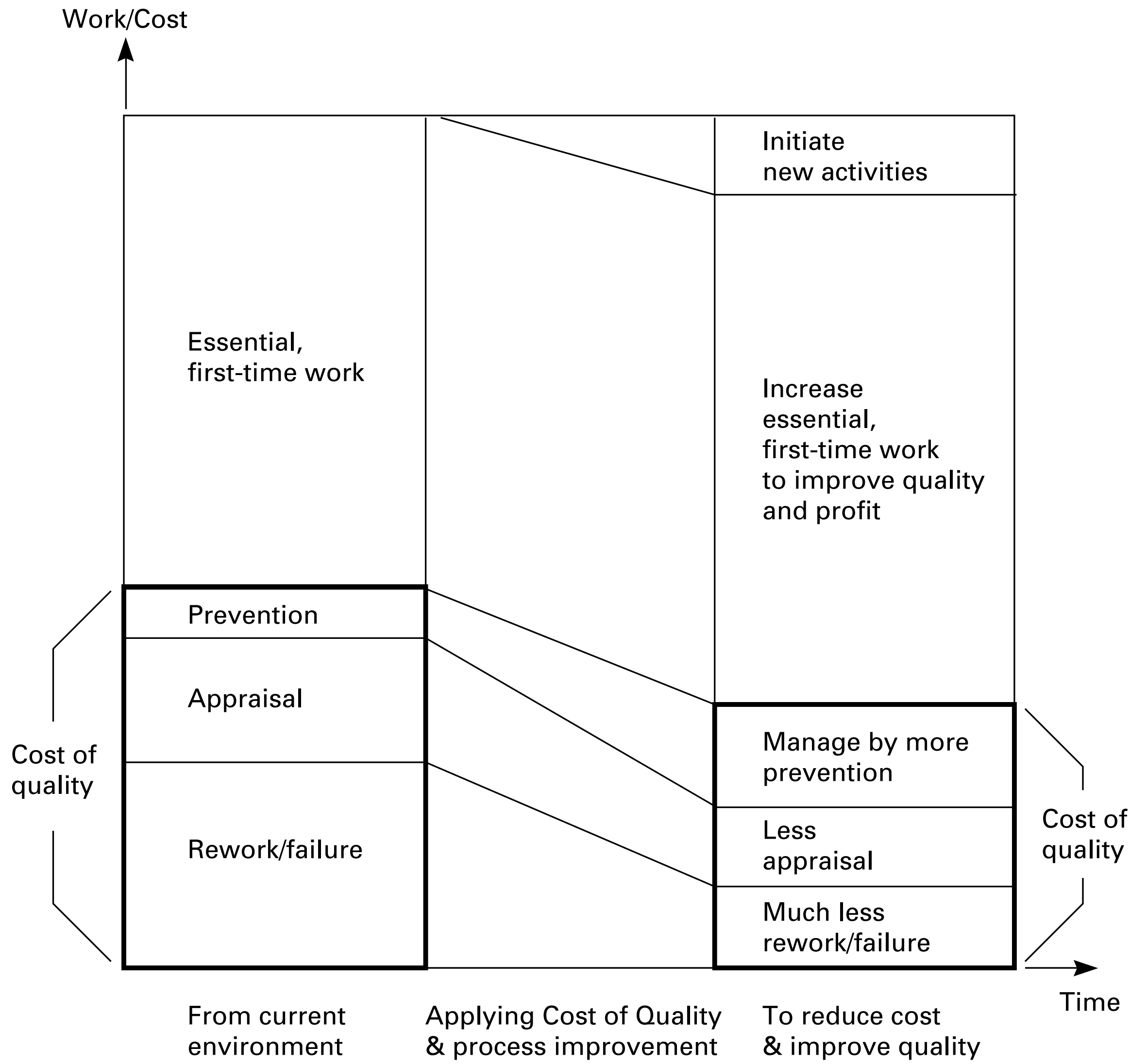

FIGURE 8.4 Effects of identifying cost of quality. (*AT&T 1990, p. 9.*)

Decisive review meetings will get bogged down in debating the validity of the figures instead of discussing the merits of the proposals for improvement.

Improved process capability: Expected savings can come from a reduction in variability (of product characteristics or process characteristics) and other process losses such as redundant operations, sorting inspections, retrieving missing information, and other non-value-added activities. As with other benefits, these expected savings must be based on improvement plans.

Reduced customer defections: One early indicator of defections can be responses to the market research question, “Would you purchase this product again?” In an early application by the author, 10.5 percent of a sample of current customers of washing machines said they would not repurchase; the reason was dissatisfaction with the machine, not with the dealer or price. At $50 profit per machine, the lost profit due to likely customer defections was then estimated. Progress has been made in quantifying the benefits of an effort to reduce defections. The parameters include the economic effect of losing customers over the “customer life,” the level of quality to retain present customers (see Section 18 under Customer Satisfaction versus Customer Loyalty), and the effect on retention of the quality of handling customer complaints (see Section 18 under Linking Customer Satisfaction Results to Customer Loyalty and to Processes). Additional discussion is provided by Rust, Zahorik, and Keiningham (1994), Chapter 6. Again, potential benefits should not be projected unless problem areas have been identified and an action plan has been formulated.

Increase in new customers: This is a most difficult benefit to quantify and predict. Quality improvements that make goods or services attractive to new customers will increase sales revenue but the amount and the timing depend on many internal actions and external market forces. Note that as the cost of poor quality is reduced, additional resources become available to finance new features for the goods and services-without increasing the price. The result can be a dramatic increase in market share.

The investments required to achieve the benefits may include diagnosis and other forms of analysis, training, redesign of products and processes, testing and experimentation, and equipment. Surprisingly, many improvement projects require little in costly equipment or facilities. The investment is mainly in analysis work.

An issue in calculating an ROQ is the matter of assumptions and estimates. Both must be realistic for the ROQ to be viewed as credible. Avoid assumptions which really represent ideal conditions; such conditions never occur. Also, the impact of numerical estimates on the ROQ can be evaluated (if necessary) using "sensitivity analysis." This involves changing the estimates (say by ±20 percent) and recalculating the ROQ to see the effect of the accuracy of the estimate on the ROQ. The ROQ will change but if the amount is small, it adds credibility to the estimates.

Note that one source of benefits (reducing the cost of errors) is based on relatively "hard" data of costs already incurred that will continue unless improvement action is instituted. A second source (reducing the cost of defections) also represents a loss (of sales revenue) already incurred. Other sources (improvement of process capability and gaining new customers) are not based on current losses but do represent important opportunity costs. In the past, because of the difficulty of quantifying other sources of benefits, the cost savings of a quality improvement program have been based primarily on the cost of errors. Advances made in quantifying the impact of quality on sales revenue, however, are making it possible to add the revenue impact to the return on quality calculation. At a minimum, the ROQ calculation can be based on savings in the cost of errors. When additional data are available (e.g., process information or market research data), then estimates for one or more of the other three sources should be included to calculate the total benefits. A note of caution: this expanded view of the cost of poor quality could mean that "traditional" quality improvement efforts (reducing cost of errors) will become entangled with other efforts (increasing sales revenue), leading to a blurring of the traditional efforts on reducing errors. We need both efforts—just as much as we need the sun and the moon.

The rate of return on an investment in quality activities translates into the ratio of average annual benefits to the initial investment. (Note that the reciprocal—investment divided by annual savings—represents the time required for savings to pay back the investment, i.e., the "payback period.") But this calculation of ROQ provides an approximate rate of return because it neglects the number of years involved for the savings and also the time value of money. A more refined approach involves calculating the "net present value" of the benefits over time. This means using the mathematics of finance to calculate the amount today which is equivalent to the savings achieved during future years (see Grant, Ireson, and Leavenworth1990, Chapter 6). Rust, Zahorik, and Keinubghan (1994) describe an approach for calculating the ROQ incorporating savings in traditional losses due to errors, sales revenue enhancement using market research information for customer retention, and the time value of money.

Wolf and Bechert (1994) describe a method to determine the payback of a reduction in failure costs when prevention and appraisal expenditures are made. Bester (1993) discusses the concept of net value productivity which addresses the cost of quality and the value of quality.

GAINING APPROVAL FOR THE QUALITY IMPROVEMENT PROGRAM

Those presenting the results of the cost study should be prepared to answer this question from management: "What action must we take to reduce the cost of poor quality?"

The control of quality in many companies follows a recognizable pattern—as defects increase, we take action in the form of more inspection. This approach fails because it does not remove the causes of defects; i.e., it is detection but not prevention. To achieve a significant and lasting reduction in defects and costs requires a structured process for attacking the main sources of loss—the failure costs. Such an attack requires proceeding on a project-by-project basis. These projects in turn require resources of various types (see Section 5, The Quality Improvement Process). The resources must be justified by the expected benefits. For every hour spent to identify one of the vital few problems, we often spend 20 hours to diagnose and solve the problem.

To gain approval from upper management for a quality improvement effort, we recommend the following steps.

1. Establish that the costs are large enough to justify action (see, for example, Tables 8.1 and 8.2).

- ***a.*** Use the grand total to demonstrate the need for quality improvement. This is the most significant figure in a quality cost study. Usually, managers are stunned by the size of the total—they had no idea the amount was so big. One memorable example was a leading manufacturer of aircraft engines. When the total quality costs were made known to the managing director, he promptly convened his senior executives to discuss a broad plan of action. Those presenting the report should be prepared for the report to be greeted with skepticism. The cost may be such that it will not be believed. This can be avoided if management has previously agreed to the definition of the cost of poor quality and if the accounting function has collected the data or has been a party to the data collection process. Also, don't inflate the present costs by including debatable or borderline items.
- ***b.*** Relate the grand total to business measures. Interpretation of the total is aided by relating total quality costs to other figures with which managers are familiar. Two universal languages are spoken in the company. At the "bottom," the language is that of objects and deeds: square meters of floor space, output of 400 tons per week, rejection rates of 3.6 percent, completion of 9000 service transactions per week. At the "top," the language is that of money: sales, profit, taxes, investment. The middle managers and the technical specialists must be *bilingual.* They must be able to talk to the "bottom" in the language of objects and to the "top" in the language of money. Table 8.4 shows actual examples of the annual cost of poor quality related to various business measures. In one company which was preoccupied with meeting delivery schedules, the quality costs were translated into equivalent added production. Since this coincided with the chief current goals of the managers, their interest was aroused. In another company, the total quality costs of $176 million per year for the company were shown to be equivalent to one of the company plants employing 2900 people, occupying 1.1 million ft^2 of space and requiring $6 million of in-process inventory. These latter three figures in turn meant the equivalent of one of their major plants making 100 percent defective work every working day of the year. This company is the quality leader in its industry. Similarly, in an airplane manufacturing company, it was found useful to translate the time spent on rework to the backlog of delivery of airplanes, i.e., reducing the rework time made more hours available for producing the airplanes.
- ***c.*** Show the subtotals for the broad major groupings of quality costs, when these are available. A helpful grouping is by the four categories discussed above under Categories of Quality Costs. Typically, most of the quality costs are associated with failures, internal and external. The proper sequence is to reduce the failure costs first, not to start by reducing inspection costs. Then as the defect levels come down, we can follow through and cut the inspection costs as well.

2. Estimate the savings and other benefits:

- ***a.*** If the company has never before undertaken an organized program to reduce quality-related costs, then a reasonable goal is to cut these costs in two, within a space of 5 years.
- ***b.*** Don't imply that the quality costs can be reduced to zero.
- ***c.*** For any benefits that cannot be quantified as part of the return on quality, present these benefits as intangible factors to help justify the improvement program. Sometimes, benefits can be related to problems of high priority to upper management such as meeting delivery

TABLE 8.4 Languages of Management

Money (annual cost of poor quality)
24% of sales revenue
15% of manufacturing cost
13 cents per share of common stock
\$7.5 million per year for scrap and rework compared to a profit of \$1.5 million per year
\$176 million per year
40% of the operating cost of a department
Other languages
The equivalent of one plant in the company making 100% defective work all year
32% of engineering resources spent in finding and correcting quality problems
25% of manufacturing capacity devoted to correcting quality problems
13% of sales orders canceled
70% of inventory carried attributed to poor quality levels
25% of manufacturing personnel assigned to correcting quality problems

schedules, controlling capital expenditures, or reducing a delivery backlog. In a chemical company, a key factor in justifying an improvement program was the ability to reduce significantly a major capital expenditure to expand plant capacity. A large part of the cost of poor quality was due to having to rework 40 percent of the batches every year. The improvement effort was expected to reduce the rework from 40 percent to 10 percent, thus making available production capacity that was no longer needed for rework.

3. Calculate the return on investment resulting from improvement in quality. Where possible, this return should reflect savings in the traditional cost of poor quality, savings in process capability improvement, and increases in sales revenue due to a reduction in customer defections and increases in new customers. See above under Return on Quality.
4. Use a successful case history (a "bellwether" project) of quality improvement in the company to justify a broader program.
5. Identify the initial specific improvement projects. An important tool is the Pareto analysis which distinguishes between the "vital few" and the "useful many" elements of the cost of poor quality. This concept and other aids in identifying projects is covered in Section 5 under Use of the Pareto Principle. An unusual application of the concept is presented in Figure 8.5. Here, in this "double Pareto" diagram, the horizontal axis depicts (in rank order) within each major category the cost of poor quality and the vertical axis shows the subcategories (in rank order) of the major category. Thus, the first two major categories (patient care–related and facility-related) account for 80 percent of the cost. Also, of the 64 percent which is patient care related about 54 percent is related to variation in hospital practice and 46 percent to outpatient thruput optimization. This graph has proven to be a powerful driver for action.
6. Propose the structure of the improvement program including organization, problem selection, training, review of progress, and schedule. See Section 5, The Quality Improvement Process. Justification is essential for an effective program of quality improvement. Approaches to justification are discussed in more detail in Section 5 under Securing Upper Management Approval and Participation.

USING COST OF POOR QUALITY CONCEPT TO SUPPORT CONTINUING IMPROVEMENT

As formal quality improvement continues with projects addressed to specific problems, the measurement of the cost of poor quality has several roles.

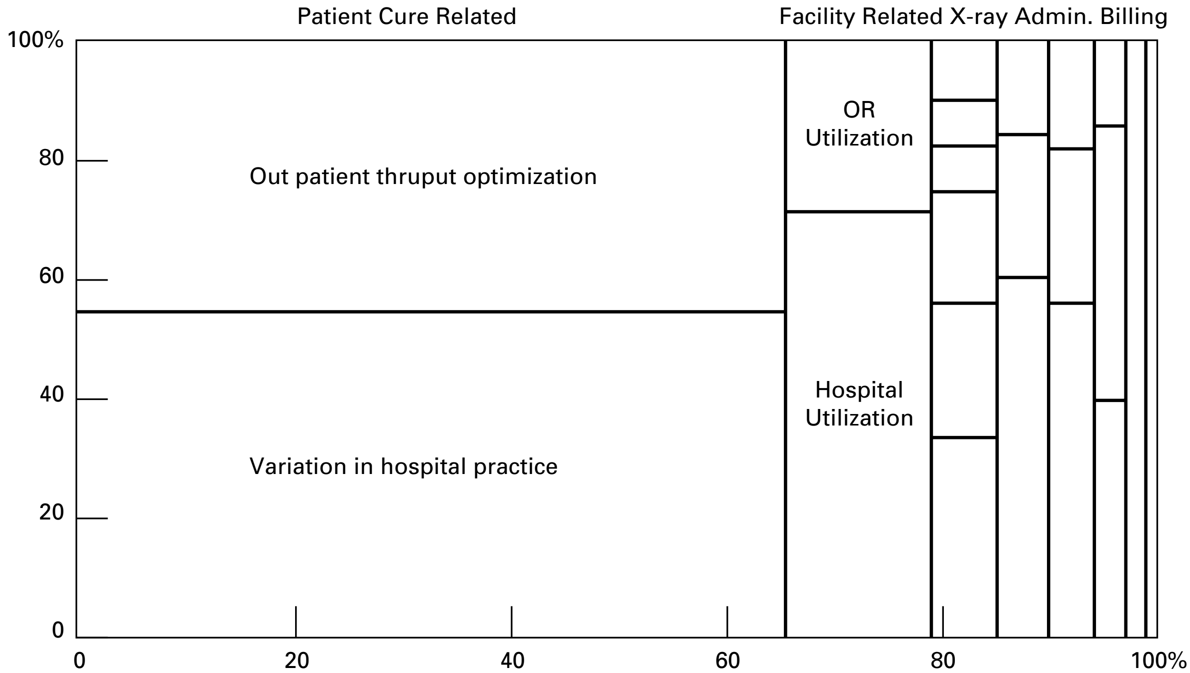

FIGURE 8.5 Mayo Rochester improvement opportunity. (*Adapted from Rider 1995.*)

Roles to Support Improvement. These include:

1. Identify the most significant losses for an individual problem and the specific costs to be eliminated. This helps to focus the diagnostic effort on root causes. Figure 8.6 shows an example of a special report that dissects one element of cost ("penalties") and summarizes data on the cost of poor quality to identify "activity cost drivers" and "root causes."
2. Provide a measure of effectiveness of the remedies instituted on a specific project. Thus, a project quality improvement team should provide for measuring the costs to confirm that the remedies have worked.
3. Provide a periodic report on specific quality costs. Such a report might be issued quarterly or semiannually.
4. Repeat the full cost of poor quality study. This study could be conducted annually to assess overall status and help to identify future projects.
5. Identify future improvement projects by analyzing the full study (see item 4 above) using Pareto analysis and other techniques for problem selection.

Note that the emphasis is on using the cost of poor quality to identify improvement projects and support improvement team efforts rather than focusing on the gloomy cost reporting.

Optimum Cost of Poor Quality. When cost summaries on quality are first presented to managers, one of the usual questions is: "What are the right costs?" The managers are looking for a standard ("par") against which to compare their actual costs so that they can make a judgment on whether there is a need for action.

Unfortunately, few credible data are available because (1) companies almost never publish such data and (2) the definition of cost of poor quality varies by company. [In one published study, Ittner (1992) summarizes data on the four categories for 72 manufacturing units of 23 companies in 5 industry sectors.] But three conclusions on cost data do stand out: The total costs are higher for complex industries, failure costs are the largest percent of the total, and prevention costs are a small percent of the total.

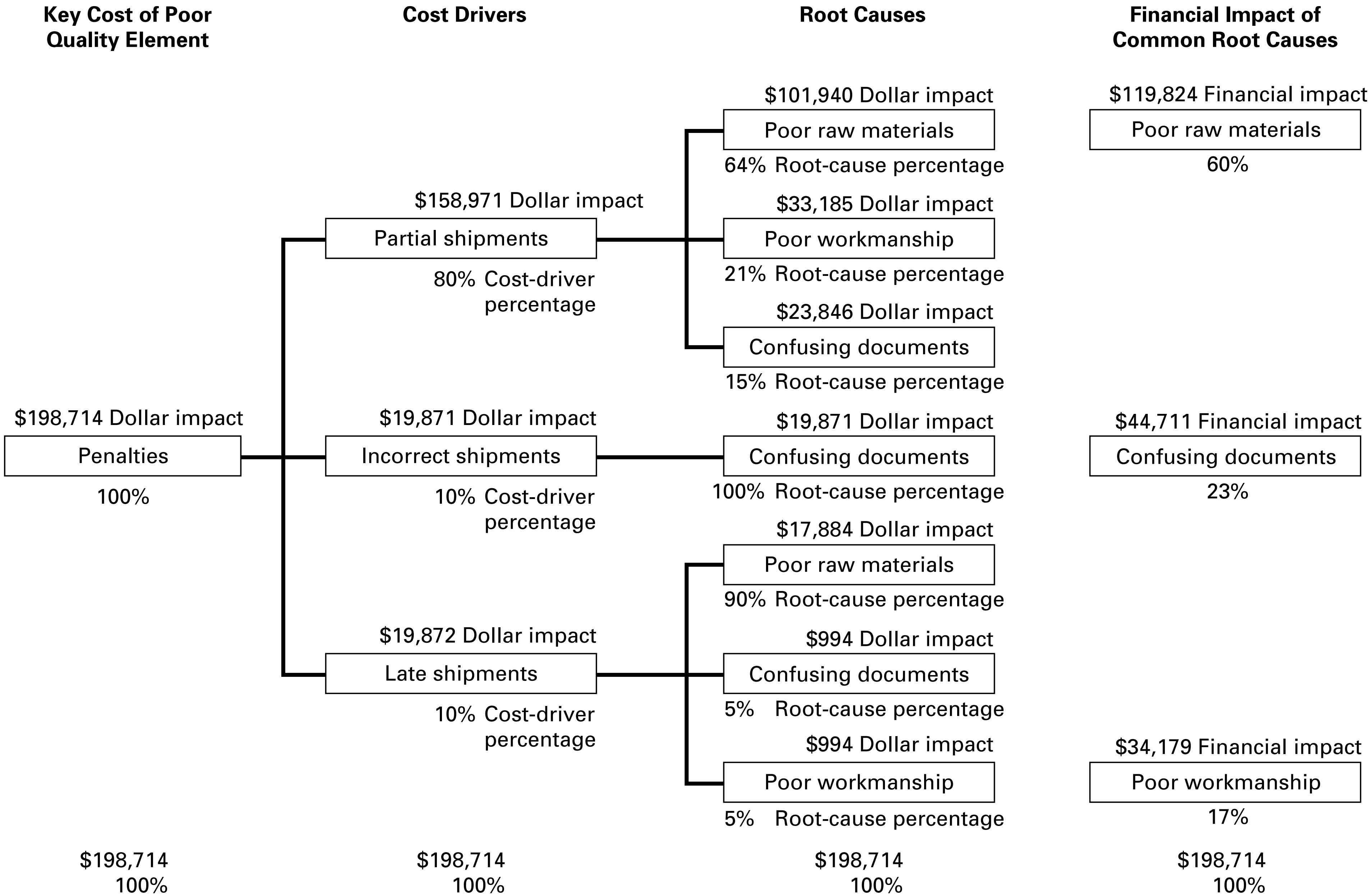

FIGURE 8.6 The completed cost-driver analysis. (*Adapted from Atkinson, Hamburg, and Ittner, 1994, p. 142.*)

The study of the distribution of quality costs over the major categories can be further explored using the model shown in Figure 8.7. The model shows three curves:

1. *The failure costs:* These equal zero when the product is 100 percent good, and rise to infinity when the product is 100 percent defective. (Note that the vertical scale is cost per good unit of product. At 100 percent defective, the number of good units is zero, and hence the cost per good unit is infinity.)
2. *The costs of appraisal plus prevention:* These costs are zero at 100 percent defective, and rise as perfection is approached.
3. *The sum of curves 1 and 2:* This third curve is marked "total quality costs" and represents the total cost of quality per good unit of product.

Figure 8.7 suggests that the minimum level of total quality costs occurs when the quality of conformance is 100 percent, i.e., perfection. This has not always been the case. During most of the twentieth century the predominant role of (fallible) human beings limited the efforts to attain perfection at finite costs. Also, the inability to quantify the impact of quality failures on sales revenue resulted in underestimating the failure costs. The result was to view the optimum value of quality of conformance as less than 100 percent.

While perfection is obviously the goal for the long run, it does not follow that perfection is the most economic goal for the short run, or for every situation. Industries, however, are facing increasing pressure to reach for perfection. Examples include:

1. *Industries producing goods and services that have a critical impact on human safety and well-being:* The manufacture of pharmaceuticals and the generation of mutual fund statements provide illustrations.
2. *Highly automated industries:* Here, it is often possible to achieve a low level of defects by proper planning of the manufacturing process to assure that processes are capable of meeting

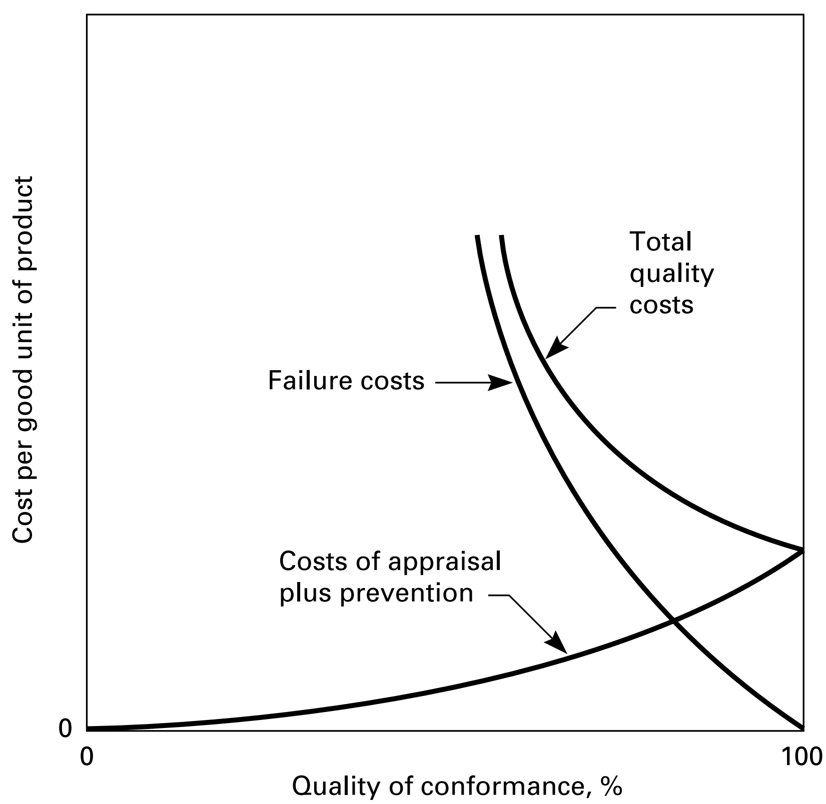

FIGURE 8.7 Model for optimum quality costs.

specifications. In addition, automated inspection often makes it economically feasible to perform 100 percent inspection to find all the defects.

3. *Companies selling to affluent clients:* These customers are often willing to pay a premium price for perfect quality to avoid even a small risk of a defect.
4. *Companies striving to optimize the user's cost:* The model depicted in Figure 8.7 shows the concept of an optimum from the viewpoint of the producer. When the user's costs due to product failure are added to such models, those costs add further fuel to the conclusion that the optimum point is perfection. The same result occurs if lost sales income to the manufacturer is included in the failure cost.

The prospect is that the trend to 100 percent conformance will extend to more and more goods and services of greater and greater complexity.

To evaluate whether quality improvement has reached the economic limit, we need to compare the benefits possible from specific projects with the costs involved in achieving these benefits. When no justifiable projects can be found, the optimum has been reached.

REPORTING ON THE COST OF POOR QUALITY

As structured quality improvement teams following the project-by-project approach have emerged as a strong force, reporting on the cost of poor quality has focused on supporting these team activities. These reports provide information which helps to diagnose the problem and to track the change in costs as a remedy is implemented to solve the problem. Regularly issued reports with a fixed format usually do not meet the needs of improvement teams. Teams may need narrowly focused information and they may need it only once. What data are needed is determined by the team, and the team often collects its own data (Winchell 1993).

Some companies use periodic reporting on the cost of poor quality in the form of a scoreboard. Such a scoreboard can be put to certain constructive uses. To create and maintain the scoreboard, however, requires a considerable expenditure of time and effort. Before undertaking such an expenditure, the company should look beyond the assertions of the advocates; it should look also at the realities derived from experience. (Many companies have constructed quality cost scoreboards and have then abandoned them for not achieving the results promised by the advocates.) After finalizing the categories for a cost scoreboard, the planning must include collecting and summarizing the data, establishing bases for comparison, and reporting the results.

Summarizing the Data. The most basic ways are

1. By product, process, component, defect type, or other likely defect concentration pattern
2. By organizational unit
3. By category cost of poor quality
4. By time

Often, the published summaries involve combinations of these different ways.

Bases for Comparison. When managers use a scoreboard on the cost of poor quality, they are not content to look at the gross dollar figures. They want, in addition, to compare the costs with some base which is an index of the opportunity for creating these costs. A summary of some widely used bases, along with the advantages and disadvantages of each, is presented in Table 8.5. The base used can greatly influence the interpretation of the cost data.

It is best to start with several bases and then, as managers gain experience with the reports, retain only the most meaningful. The literature stresses that quality costs be stated as percent of sales income. This is a useful base for some, but not all, purposes.

TABLE 8.5 Measurement Bases for Quality Costs

Base	Advantages	Disadvantages
Direct labor hour	Readily available and understood	Can be drastically influenced by automation
Direct labor dollars	Available and understood; tends to balance any inflation effect	Can be drastically influenced by automation
Standard manufacturing cost dollars	More stability than above	Includes overhead costs both fixed and variable
Value-added dollars	Useful when processing costs are important	Not useful for comparing different types of manufacturing departments
Sales dollars	Appeals to higher management	Sales dollars can be influenced by changes in prices, marketing costs, demand, etc.
Product units	Simplicity	Not appropriate when different products are made unless "equivalent" item can be defined

Reporting the Results. The specific matters are the same as for those for other reports—format, frequency, distribution, responsibility for publication. Atkinson, Hamburg, and Ittner (1994) describe how reporting can help promote a cultural change for quality, Dobbins and Brown (1989) provide "tips" for creating reports, and Onnias (1985) describes a system used at Texas Instruments.

The likely trend is for cost of poor quality and other quality-related information to become integrated into the overall performance reporting system of organizations. Kaplan and Norton (1996) propose that such a system provide a "balanced scorecard." Such a scorecard allows managers to view an organization from four perspectives:

1. How do customers see us? (Customer perspective.)
2. What must we excel at? (Internal perspective.)
3. Can we continue to improve and create value? (Innovation and learning perspective.)
4. How do we look to shareholders? (Financial perspective.) The scorecard would include a limited number of measures—both the financial result measures and the operational measures that drive future financial performance.

Periodically (say annually), a comprehensive report on the cost of poor quality is useful to summarize and consolidate results of project teams and other quality improvement activities. The format for this report need not be identical to the initial cost of poor quality study but should (1) reflect results of improvement efforts and (2) provide guidance to identify major areas for future improvement efforts.

ECONOMIC MODELS AND THE COST OF POOR QUALITY

The costs of poor quality affect two parties—the provider of the goods or service and the user. This section discusses the impact on the provider, i.e., a manufacturer or a service firm. Poor quality also increases the costs of the user of the product in the form of repair costs after the warranty period, various losses due to downtime, etc. Gryna (1977) presents a methodology with case examples of user costs of poor quality. The extent of these user costs clearly affects future purchasing decisions of the user and thereby influences the sales income of the provider. This section stresses the potential for profit improvement by reducing provider costs and by reducing loss of sales revenue due to poor quality.

An extension of this thinking is provided by applying concepts from the economics discipline. Cole and Mogab (1995) apply economic concepts to analyze the difference between the "mass production/scientific management firm" and the "continuous improvement firm" (CIF). A defining feature of the CIF is the ability to add to the net customer value of the marketed product. The net customer value is defined as the total value realized by the customer from the purchase and use of the goods or service less that which must be sacrificed to obtain and use it. In terms of the economy of countries, Brust and Gryna (1997) discuss five links between quality and macroeconomics.

From the birth of the cost of poor quality with the emphasis on the cost of errors in manufacturing, the concept is now extended in the scope of cost elements and applies to manufacturing and service industries in both the profit and nonprofit sectors.

REFERENCES

AT&T (1990). *AT&T Cost of Quality Guidelines.* Document 500-746, AT&T's Customer Information Center, Indianapolis, IN.

Atkinson, Hawley, Hamburg, John, and Ittner, Christopher (1994). *Linking Quality to Profits.* ASQ Quality Press, Milwaukee, and Institute of Management Accountants, Montvale, NJ.

Atkinson, John Hawley, et al. (1991). *Current Trends in Cost of Quality: Linking the Cost of Quality and Continuous Improvement.* Institute of Management Accountants, Montvale, NJ.

Aubrey, Charles A., II (1988). "Effective Use of Quality Cost Applied to Service." *ASQC Quality Congress Transactions,* Milwaukee, pp. 735–739.

Bester, Yogi (1993). "Net-Value Productivity: Rethinking the Cost of Quality Approach." *Quality Management Journal,* October, pp. 71–76.

Bohan, George P., and Horney, Nicholas F. (1991). "Pinpointing the Real Cost of Quality in a Service Company." *National Productivity Review,* Summer, pp. 309–317.

Briscoe, Nathaniel R., and Gryna, Frank M. (1996). *Assessing the Cost of Poor Quality in a Small Business.* Report No. 902, College of Business Research Paper Series, The University of Tampa, Tampa, FL.

Brust, Peter J., and Gryna, Frank M. (1997). *Product Quality and Macroeconomics—Five Links.* Report No. 904, College of Business Research Paper Series, The University of Tampa, Tampa, FL.

Campanella, Jack, Ed. (1999). *Principles of Quality Costs,* 3rd ed., ASQ, Milwaukee.

Carr, Lawrence P. (1992). "Applying Cost of Quality to a Service Business." *Sloan Management Review,* Summer, pp. 72–77.

Cole, William E., and Mogab, John W. (1995). *The Economics of Total Quality Management: Clashing Paradigms in the Global Market.* Blackwell, Cambridge, MA.

Dawes, Edgar W., and Siff, Walter (1993). "Using Quality Costs for Continuous Improvement." *ASQC Annual Quality Congress Transactions,* Milwaukee, pp. 810–816.

Dobbins, Richard K., and Brown, F. X. (1989). "Quality Cost Analysis—Q.A. Versus Accounting." *ASQC Annual Quality Congress Transactions,* pp. 444–452.

Esterby, L. James (1984). "Measuring Quality Costs by Work Sampling." *Quality Costs: Ideas and Applications.* Andrew F. Grimm, Louis A. Pasteelnick, and James F. Zerfas, eds., ASQC Quality Press, Milwaukee, pp. 487–491.

Finnegan, John T., and Schottmiller, John C. (1990). "Cost of Quality—Multinational and Multifunctional." *ASQC Quality Congress Transactions,* Milwaukee, pp. 746–751.

Garrison, Ray H., and Noreen, Eric W. (1994). *Managerial Accounting.* Irwin, Boston.

Grant, Eugene L., Ireson, W. Grant, and Leavenworth, Richard S. (1990). *Principles of Engineering Economy,* 8th ed., John Wiley and Sons, New York.

Gryna, Frank M. (1977). "Quality Costs: User vs. Manufacturer." *Quality Progress,* June, pp. 10–15.

Harrington, H. James (1986). *Poor Quality Cost.* ASQC Quality Press, Milwaukee, and Marcel Dekker, New York.

Hester, William F. (1993). "True Quality Cost With Activity Based Costing." *ASQC Annual Quality Congress Transactions,* Milwaukee, pp. 446–454.

Hou,Tien-fang (1992). "Cost-of-Quality Techniques for Business Processes." *ASQC Annual Quality Congress Transactions,* Milwaukee, pp. 1131–1137.

ISO 9004-1 (1994). *Quality Management and Quality System Elements—Guidelines,* Section 6, "Financial Considerations of Quality Systems." ISO, Geneva.

Ittner, Christopher Dean (1992). *The Economics and Measurement of Quality Costs: An Empirical Investigation.* Doctoral dissertation, Harvard University, Cambridge, MA.

Kaplan, Robert S., and Norton, David P. (1996). *The Balanced Scorecard,* Harvard Business School Press, Boston.

Keaton, Willie E., et al. (1988). "White Collar Quality Pinpointing Areas for Breakthrough." *IMPRO 1988 Conference Proceedings,* Juran Institute, Inc., Wilton, CT., pp. 3C-19 to 3C-24.

Krause, James D., and Gryna, Frank M. (1995). *Activity Based Costing and Cost of Poor Quality—a Partnership.* Report No. 109, College of Business Research Paper Series, The University of Tampa, Tampa, FL.

Nickell, Warren L. (1985). "Quality Improvement in Marketing." *The Juran Report,* no. 4 (Winter), pp. 29–35.O'Neill, Ann R. (1988). "Quality Costs In = Continuous Improvement Out." *ASQC Annual Quality Congress Transactions,* Milwaukee, pp. 180–187.

Onnias, Arturo (1985). "The Quality Blue Book." *IMPRO 1985 Conference Proceedings,* Juran Institute, Inc., Wilton, CT, pp. 127–134.

Quevedo, Rene (1991). "Quality, Waste, and Value in White-Collar Environments." *Quality Progress,* January, pp. 33–37.

Reeve, J. M. (1991). "Variation and the Cost of Quality." *Quality Engineering,* vol. 4, no. 1, pp. 41–55.

Rider, C. T. (1995). "Aligning Your Improvement Strategy for the Biggest Payback." *IMPRO 1995 Conference Proceedings,* Juran Institute Inc., Wilton, CT, pp. 7E. 1-1 to 7E.1-11.

Romagnole, Anthony J., and Williams, Mary A. (1995). "Costs of Poor Quality." *IMPRO 1995 Conference Handout,* Juran Institute, Inc., Wilton, CT.

Rust, Roland T., Zahorik, Anthony J., and Keiningham, Timothy L. (1994). *Return on Quality.* Probus, Chicago.

Schottmiller, John C. (1996). "ISO 9000 and Quality Costs." *ASQC Annual Quality Congress Proceedings,* Milwaukee, pp. 194–199.

Schrader, Lawrence, J. (1986). "An Engineering Organization's Cost of Quality Program." *Quality Progress,* January, pp. 29–34.

Shepherd, Nick A. (1998). "Cost of Quality and ISO Implementation Using Cost of Quality as a Driver for Effective Use of ISO 9000 and 14000." *ASQ Annual Quality Congress Transactions,* pp. 776–783.

The Conference Board (1989). *Current Practices in Measuring Quality.* Research Bulletin No. 234, New York.

The University of Tampa (1990). "Costly Mistakes." *Visions,* Fall, p. 7.

Wasserman, Gary S., and Lindland, John L. (1994). "Minimizing the Cost of Quality Over Time: A Dynamic Quality Cost Model." *ASQC Annual Quality Congress Proceedings,* pp. 73–81.

Wild, Cheryl, and Kovacs, Carol (1994). "Cost-of-Quality Case Study." *IMPRO 1994 Conference Proceedings,* Juran Institute, Inc., Wilton, CT, pp. 3B-19 to 3B-29.

Winchell, William O. (1991). "Implementation of Quality Costs—Making It Easier." *ASQC Annual Quality Congress Transactions,* Milwaukee, pp. 592–597.

Winchell, William O. (1993). "New Quality Cost Approach Gives Proven Results." *ASQC Annual Quality Congress Transactions,* Milwaukee, pp. 486–492.

Wolf, C., and Bechert, J. (1994). "Justifying Prevention and Appraisal Quality Cost Expenditures: A Benefit/Cost Decision Model." *Quality Engineering,* vol. 7, no. 1, pp. 59–70.