Designing a Productive System: The Cost of Quality

The Cost of Quality

According to legendary quality guru Armand Feigenbaum, "quality costs are the foundation for quality-systems economic."

Quality costs have traditionally served as the basis for evaluating investments in quality programs.

The cost of quality are those incurred to achieve good quality and to satisfy the customer, as well as the costs incurred when quality fails to satisfy the customer.

The Cost of Quality

Thus, quality costs fall into two categories: the cost of achieving good quality, also known as the ***cost of quality assurance,*** and the cost associated with poor-quality products, also referred to as ***cost of not conforming*** to specifications.

The Cost of Achieving Good Quality

The costs of a quality-management program are ***prevention costs*** and ***appraisal costs.***

Prevention Costs are the costs of trying to prevent poor-quality products from reaching the customer. Prevention reflects the quality philosophy of "do it right the first time," the goal of quality management program.

Examples of prevention costs include:

1. Quality planning costs – the costs of developing and implementing quality management program.

The Cost of Achieving Good Quality

2. Product-design costs – the costs of designing products with quality characteristics.
3. Process costs – the costs expended to make sure that the productive process conforms to quality specifications.
4. Training costs – the costs of developing and putting on quality training programs for employees and management.

The Cost of Achieving Good Quality

5. Information costs – The costs of acquiring and maintaining data related to quality and development and analysis of reports on quality performance.

The Cost of Achieving Good Quality

Appraisal Costs are the costs of measuring, testing, and analyzing materials, parts, products, and the productive process to ensure that the product-quality specifications are being met.

Examples of appraisal costs include:

1. Inspection and Testing – the costs of inspecting materials, parts and product at various stages and at the end of the process.

The Cost of Achieving Good Quality

2. Test equipment costs – the costs of maintaining equipment used in testing the quality characteristics of products.
3. Operator costs – the costs time spent by operators to gather data for testing product quality, to make equipment adjustments to maintain quality, and to stop work to assess quality.

The Cost of Achieving Good Quality

Appraisal cost tend to be higher in a service organization than in manufacturing company and, therefore, are a greater proportion of total quality costs.

Quality in services is related primarily to the interaction between an employee and a customer, which makes the cost of appraising quality more difficult.

Quality appraisal in a manufacturing operation can take place almost in-house; appraisal of service quality requires customer interviews, surveys , questionnaires, and the like.

The Cost of Poor Quality

Costs associated with poor quality are also referred to as costs of non-conformance, or failure costs. The cost of failures is the difference between what it actually costs to produce or deliver a service and what it would cost if there were no failures.

This is generally the largest quality cost category in a company, frequently accounting for 70 to 90% of total quality costs. This is where the greatest cost improvement is possible.

The Cost of Poor Quality

The cost of poor quality can be categorized as internal failure costs and external failure costs.

Internal failure costs are incurred when poor-quality products are discovered before they are delivered to the customer.

Examples are:

1. **Scrap costs** – the cost of poor-quality products that must be discarded, including labor, material and indirect costs.

The Cost of Poor Quality

2. **Rework costs** – the cost of fixing defective products to conform to quality specifications.
3. **Process failure costs** – the cost of determining why the production process is producing poor-quality products.
4. **Process downtime costs** – the costs of shutting down the productive process to fix the problem.
5. **Price-downgrading costs** - the costs of discounting poor-quality products – that is, selling the products as "seconds."

The Cost of Poor Quality

External failure costs are incurred after the customer has received a poor-quality product and are primarily related to customer service. Examples are:

1. **Customer complaint costs** – the cost of investigating and satisfactorily responding to a customer complaint resulting from a poor-quality product.
2. **Product return costs** – the cost of handling and replacing poor-quality products returned by the customer.
3. **Warranty claims costs** – the costs of complying with product qualities.

The Cost of Poor Quality

4. **Product liability costs** – the litigation costs resulting from product liability and customer inquiry.
5. **Lost sales costs** – the cost incurred because customers are dissatisfied with poor-quality products and do not make additional purchases.

Internal failure costs tends to be low for a service, whereas external failure costs can be quite high.

The Cost of Poor Quality

A service organization has little opportunity to examine and correct a defective internal process, usually an employee-customer interaction, before it actually happens. At that point it becomes and external failure.

External failures typically result in an increase in service time or inconvenience for the customer.

The Cost of Poor Quality

Examples of external failures include:

1. Waiting too long to place a catalogue phone order;
2. A catalogue order that arrives with the wrong item, requiring the customer to repackage and send it back;
3. An error in a charge card billing statement, requiring the customer to make phone calls or write letters to correct it;
4. Sending a customer's orders or statements to wrong address;
5. An overnight mail package that does not arrive overnight.

Measuring & Reporting Quality Costs

Collecting data on quality costs can be difficult. The costs of lost sales, of responding to customer complaints, of process downtime, of operator testing, of quality information, and of quality planning and product design are all costs that may be difficult to measure.

These costs must be estimated by management.

Measuring & Reporting Quality Costs

Training costs, inspection and testing costs, scrap costs, the costs of product downgrading, product return costs, warranty claims, and liability costs can usually be measured.

Many of these costs are collected as part of normal accounting procedures.

Management wants quality costs reported in a manner that can be easily interpreted and is meaningful.

One format for reporting quality costs is with **index numbers or indices.**

Measuring & Reporting Quality Costs

Index numbers are ratios that measure quality costs relative to some base value, such as the ratio of quality costs to total sales revenue or the ratio of quality costs to units of final product.

These index numbers are used to compare quality management efforts between time periods or between departments or functions. Index numbers themselves do not provide very much information about the effectiveness of a quality-management program.

Measuring & Reporting Quality Costs

They usually will not show directly that a company is producing good- or poor-quality products. These measures are informative only when they are compared to some standard or other index.

Some common index measures are:

1. Labor index
2. Sales index
3. Cost index
4. Production index

Measuring & Reporting Quality Costs

1. **Labor index** – the ratio of quality cost to direct labor hours; it has the advantage of being easily computed (from accounting records) and easily understood, but it is not always effective for long-term comparative analysis when technological advances reduce labor usage.
2. **Sales index** – the ratio of quality cost to sales; it is easily computed, but it can be distorted by changes in selling price and costs.

Measuring & Reporting Quality Costs

3. **Cost index** – the ratio of quality cost to manufacturing cost (direct and indirect cost); it is easy to compute from accounting records and is not affected by technological change.
4. **Production index** – the ratio of quality cost to units of final product; it is easy to compute from accounting records but is not effective if a number of different products exist.

Sample Problem 1

The Malvulacan Motor Company produces small 3hp-motors for use in lawnmowers and garden equipment. The company instituted a quality-management program in 2011 and has recorded the quality cost data and accounting measures for four years. The company wants to asses its quality-assurance program and develop quality index numbers using sales and manufacturing cost bases for the four-year period.

Sample Problem 1

	Year			
	2011	2012	2013	2014
Quality Cost				
Prevention	$ 27,000	$ 41,500	$ 74,600	$ 112,300
Appraisal	$ 155,000	$ 122,500	$ 113,400	$ 107,000
Internal failure	$ 386,000	$ 469,200	$ 347,800	$ 219,100
External failure	$ 242,000	$ 196,000	$ 103,500	$ 106,000
Total	$ 810,400	$ 829,200	$ 639,300	$ 544,400
Accounting Measures				
Sales	$ 4,360,000	$ 4,450,000	$ 5,050,000	$ 5,190,000
Manufacturing costs	$ 1,760,000	$ 1,810,000	$ 1,880,000	$ 1,890,000

Sample Problem 1

Observations & Assessments:

- Malvulacan Motor Company (MMC) experienced many of the typical outcomes when its quality-assurance program was instituted.
- Approx. 78% of MMC's total quality costs are a result of internal and external failures
- Failure costs frequently contribute 50-90% of overall quality costs
- In 2012, MMC was able to identify more defective items, resulting in increase in internal failure costs of and lower external failure costs

Sample Problem 1

Solutions & Adjustments made:

- Due to high failure costs in 2011 & 2012, MCC increased the product monitoring and inspection that results in eliminating poor-quality products, resulting in high appraisal costs.
- In 2011 & 2012 prevention were modest, however, prevention is critical in reduction of internal and external failures, that's why MMC instituted quality training programs, redesign the production process and build product quality that prevents poor-quality products within the production process and prevent them from reaching the customer.

Sample Problem 1

Solutions & Adjustments made:

- MMC also developed index numbers using quality costs as a proportion of sales and manufacturing costs.

  General formula for Quality Index (QI)

  $$Q.I. = \frac{total\ quality\ costs}{base}(100)$$

- Summary of the Quality salex index and manufacturing cost index are showed in the table for 2011 – 2014

Sample Problem 1

YEAR	QUALITY COST INDEX	QUALITY MANUFACTURING COST INDEX
2011	18.58	46.04
2012	18.63	45.18
2013	12.66	34.00
2014	10.49	28,80

Effect of Quality Management on Productivity

An effective quality-management program can help to reduce quality-related costs and improve market share and profitability.

Quality management can also improve productivity – that is, the number of units produced from available resources.

Productivity is a measure of company's effectiveness in converting inputs into outputs.

Effect of Quality Management on Productivity

An output is the final product from a service or production process, such as an automobile, a hamburger, a sale or a catalogue order.

Inputs are the parts, material, labor, capital and so on that go into the production process.

Productivity measures, depending on the outputs and inputs, are labor productivity (output per labor-hour) and machine productivity (output per machine-hour).

Effect of Quality Management on Productivity

Improving quality by reducing defects will increase good output and reduce inputs.

In fact, virtually all aspects of quality improvement have a favorable impact on different measures of productivity.

Improving product design and production processes, improving quality of materials and parts and improving job designs and work activity will all increase productivity.

Measuring Product Yield and Productivity

Product Yield is a measure of output used as an indicator of productivity. It can be computed for the entire production process (or for one stage in the process) as follows:

Yield = (total input)(% good units) + (total input)(1-%good units)(% reworked)

$$Y = (I)(\%G) + (I)(1 - \%G)(\%R)$$

Measuring Product Yield and Productivity

$$Y = (I)(\%G) + (I)(1 - \%G)(\%R)$$

I = planned number of units of product started in the production process

%G = percentage of good units produced

%R=percentage of defective units that are successfully reworked

In this formula, yield is the sum of the percentage of products started in the process that will turn out to be good quality plus percentage defective that are reworked. Improved quality will increase product yield.

Measuring Product Yield and Productivity Sample Problem 2

The MMC starts production for a particular type of motor with a steel motor housing the production process begins with 100 motors each day. The percentage of good motors produced each day averages 80% and the percentage of poor-quality motors that can be reworked is 50%. The company wants to know the daily product yield and the effect on productivity if the daily percentage of good-quality motors is increased to 90%. (Solutions on the board)

Measuring Product Yield and Productivity Sample Problem 3

A manufacturing company has a weekly product input of 1700 units. The average percentage of good-quality products is 83%. Of the poor-quality products, 60% can be reworked and sold as good-quality products. Determine the weekly product yield and the product yield if the good-product quality is increased to 92%. (Solutions on the board)

Measuring Product Yield Productivity

We will expand measuring of productivity to include product manufacturing cost. The manufacturing cost per (good) product is computed by dividing the sum of total direct manufacturing cost and total cost for all reworked units by the yield, as follows:

$$\text{Product Cost} = \frac{(direct\ mfg.\ cost\ /\ unit)(input) + (rework\ cost/\ unit)(reworked\ units)}{yield}$$

Measuring Product Yield Productivity

$$\text{Product Cost} = \frac{(direct\ mfg.\ cost\ /\ unit)(input) + (rework\ cost/\ unit)(reworked\ units)}{yield}$$

$$\text{Product Cost} = \frac{(K_d)(I)+(K_r)(R)}{Y}$$

K_d = direct manufacturing cost per unit

I = input

Kr = rework cost per unit

R = reworked units

Y = yield

Sample Problem 4

The MMC has a direct manufacturing cost per unit of $30 and motors that are of inferior quality can be worked for $12 per unit. 100 motors are produced daily, 80% (on average) are of good quality and 20% are defective. Of the defective motors, half can be reworked to yield good-quality products. Through its quality-management program, the company has discovered a problem in its production process that, when corrected (at minimum cost), will increase the good-quality products to 90%. The company wants to assess the impact on the direct cost per unit of improvement in product quality.

Measuring Product Yield for a Multi-stage Process

From previous problems, we measure productivity for a single production process only.

However, it is more likely that product quality would be monitored throughout the production process at various stages.

Each stage would result in a portion of good quality, “work-in-process” products.

Measuring Product Yield for a Multi-stage Process

For a production process with n stages, the yield, Y, without reworking is:

$$Y = (I)(\%g_1)(\%g_2)\ldots(\%g_n)$$

I = input of items to the production process that will result in finished products

g_i = good-quality, work-in-process products at stage i

Measuring Yield for Multi-stage Process Sample Problem 5

At MMC, motors are produced in a four-stage process. Motors are inspected following each stage, with percentage yields (on average) of good-quality, work-in-process units as stated in the table below.

The company wants to know the daily product yield for product input of 100 units per day. Furthermore, the company wants to know how many inputs it would have to start with each day to result in a final daily yield of 100 good-quality units.

Measuring Yield for Multi-stage Process Sample Problem 5

MMC's Percentage Yields (on average) of good-quality, work-in-process units:

Stage	Average Percentage Good Quality
1	0.93
2	0.95
3	0.97
4	0.92

The Quality-Productivity Ratio

Another measure of the effect of quality on productivity combines the concepts of quality index numbers and product yield, called the quality-productivity ratio (QPR), and is computed as follows:

$$QPR = \frac{good-quality\ units}{(input)(processing\ cost) + (defective\ units)(rework\ cost)}(100)$$

This is actually a quality index number that includes productivity and quality costs.

The Quality-Productivity Ratio

The QPR increases if either processing cost or rework costs or both decrease. It increases if more good-quality units are produced relative to total product input (i.e., the number of units that begin the production process).

The Quality-Productivity Ratio
Sample Problem 5

MMC produces small motors at a processing cost of $30 per unit. Defective motors can be reworked at a cost of $12 each. The company produces 100 motors per day and averages 80% good-quality motors, resulting in 20% defects, 50% of which can be reworked prior to shipping customers.

The company wants to examine the effects of (1) increasing the production rate to 200 motors per day; (2)reducing the processing cost to $26 and the rework cost to $10; (3) increasing, through quality improvement, the product yield of good-quality products to 95%; and (4) the combination of 2 and 3.

Midterm: Activity 5 Quality Index Problem No.1

Ingalla Philippines, Inc., produces expensive water-repellent, down-lined parkas. The company implemented a total quality-management program in 2010. They accumulated quality-related accounting data for the past 5 years after the program starts.

(a) Compute the company's total failure costs as a percentage of total quality costs for each of the five years. Does there appear to be a trend to this result? If so, speculate on what might have caused the trend.

(b) Compute prevention costs and appraisal costs, each as a percentage of total costs, during each of the five years. Speculate on what the company's quality strategy appears to be.

Midterm: Activity 5 Quality Index Problem No.1

(c) Compute quality-sales indices and quality-cost indices for each of the five years. Is it possible to assess the effectiveness of the company's quality-management program from these index values?

(d) List several examples of each quality-related cost – that is, prevention, appraisal, and internal and external failure – that might result from the production of parkas.

Midterm: Activity 5 Quality Index
Problem No.1

	YEAR				
	2010	2011	2012	2013	2014
QUALITY COSTS ($)					
PREVENTION	3.2	10.7	28.3	42.6	50.0
APPRAISAL	26.3	29.2	30.6	24.1	19.6
INTERNAL FAILURE	39.1	51.3	48.4	35.9	32.1
EXTERNAL FAILURE	118.6	110.5	105.2	91.3	65.2
ACCOUNTING MEASURES ($)					
SALES	2,700.6	2690.1	2,705.3	2,810.2	2,880.7
MANUFACTURING COST	420.9	423.4	424.7	436.1	435.5

Activity 5: Quality Index Problem No.2

Air Jo-mar Shoes, Inc. manufactures a number of different styles of athletic shoes. Its biggest seller is the Air-peds Raja basketball shoes. In 2012, the company implemented a quality management program.

Part I. The company's shoe production for the past three years and manufacturing costs are as follows:

	YEAR		
	2012	2013	2014
Units produced/input	32,000	34,600	35,500
Manufacturing Cost	$278,000	291,000	305,500
Percent good quality	78%	83%	90%

Activity 5: Quality Index Problem No.2

Only one-quarter of the defective shoes can be reworked, at a cost of $2 a piece. Compute the manufacturing cost per good for each of the three years and indicate the annual percentage increase or decrease resulting from the quality-management program.

Part II. The total processing cost for producing the Air-peds Raja basketball shoe is $18. The company starts production of 650 pairs of the shoes weekly, and the average weekly yield is 90%, with 10% defective shoes.

Activity 5: Quality Index Problem No.2

One quarter of the defective shoe can be reworked at a cost of $3.75.

(a) Compute the quality-productivity ratio (QPR).

(b) Compute the QPR if the production rate is increased to 800 pairs of shoes per week.

(c) Compute the QPR if the processing cost is reduced to $16.50 and the rework cost to $3.20.

(d) Compute the QPR if the product yield is increased to 93% good quality.

Activity 5: Problem No. 3 – Pareto Law

OLPATS is a major state university located in a small college town. Olpats Services is an incorporated university entity that operates two bookstores, one on campus and one off campus at a nearby mall.

The on-campus store sells school supplies, textbooks, and school-licensed apparel and gifts and it has a large computer department. The off-campus store sells textbooks, school supplies, and licensed-school apparel and gifts and has a large trade book department.

Activity 5: Problem No. 3 – Pareto Law

Although sales and profits at the bookstore have been satisfactory and steady over the past few years, the Board of Directors is extremely sensitive to criticism about anything that might have the potential to embarrass the university.

So they conducted a customer survey during a two-week period in the middle of the semester at both stores.

Using the observations of the operation and the survey result:

Activity 5: Problem No. 3 – Pareto Law

Develop Pareto charts to help analyze the survey results.

(a) How would you define quality at the bookstore?

(b) Discuss what you believe are the quality problems the bookstore have?

(c) What are the bookstore's cost of poor quality?

(d) What actions or programs would you propose to improve quality at the bookstores?

Questionnaires	Campus Store				Off-Campus Store			
	Student		Non-student		Student		Non-student	
	Yes	No	Yes	No	Yes	No	Yes	No
Were employees courteous and friendly?	572	93	286	147	341	114	172	156
Were employees knowledgeable and helpful?	522	143	231	212	350	105	135	193
Was the overall service good?	569	96	278	165	322	133	180	148
Did you have to wait long for service?	74	591	200	243	51	404	150	178
Did you have to wait long to check out?	81	584	203	240	72	383	147	181
Was the item you wanted available?	602	63	371	72	407	48	296	32
Was the cost of your purchase reasonable?	385	280	398	45	275	180	301	27
Have you visited the store's website?	335	330	52	391	262	193	17	311