Definition of Quality

Quality is the totality of features and characteristics of a product or service that bears on its ability to satisfy a given need. - American Society of Quality Control – Standard A3-1987, – BS 4778 (1987), ISO 8402 (1986)

Quality refers to an equilibrium level if functionality possessed by a product or service based on the producer's capability and customer's need. – Badiru and Ayeni (1993)

Fitness for purpose or use – Juran

Quality should be aimed at the needs of the customer, present and future. – Deming

The total composite product and service characteristics of marketing, engineering, manufacturing and maintenance through which the product or service in use will meet the expectation by the customer. – Feigenbaum

Conformance to requirements - Crosby

Defining Quality- Different Views

- Customer's view (more subjective)
  - the quality of the design (look, feel, function)
  - product does what's intended and lasts
- Producer's view
  - conformance to requirements (Crosby)
  - costs of quality (prevention, scrap, warranty)
  - increasing conformance raises profits
- Government's view
  - products should be safe
  - not harmful to environment

Stout's view

Quality = Performance/Expectation

History of Quality Paradigms

- **Customer-craft quality paradigm**:
  - design and build each product for a particular customer.
  - producer knows the customer directly.
- **Mass production and inspection quality paradigm**:
  - focus on designing and building products for mass consumption.
  - larger volumes will reduce costs and increases profits.
  - push products on the customer (limit choices).
  - quality is maintained by inspecting and detecting bad products.
- **TQM or "Customer Driven Quality" paradigm**:
  - potential customers determine what to design and build.
  - higher quality will be obtained by preventing problems

Quality Gurus

W. Edwards Deming

- Emphasis on statistical methods in quality improvement (see Deming's 14 points)

Joseph Juran

- Emphasis on managerial role in quality implementation

Armand V. Feigenbaum

- Emphasis on organizational structure

Business Functions and their Responsibilities for Quality

- **Top management:** Top-level support and encouragement of quality effort
- **Quality control:** Quality assurance plus promotion, coordination and control of entire quality effort
- **Accounting:** Measurement of quality costs and quality effort
- **Research:** Quality of research – Proper design and analysis of experimental data
- **Sales and marketing:** Selling a quality product and providing information on field performance

- **Design Engineering:** Designing a quality product and changing the design to achieve optimal quality condition
- **Tool Engineering:** Providing quality tools, jigs and fixtures
- **Production Engineering:** Providing a quality production process
- **Purchasing:** Quality of conformance of purchased goods, feedback of quality information
- **Manufacturing:** Quality conformance in manufacturing, semi-finished and finished goods, feedback of quality information

Quality Characteristics

- **Structural characteristics** include such elements as the length of a part, the weight of a can, the strength of a beam, the viscosity of a fluid, and so on

- **Sensory characteristics** include the taste of good food, the smell of a sweet fragrance etc.

- **Time-oriented characteristics** include such measures as a warranty, reliability, and maintainability

- **Ethical characteristics** include honesty, courtesy, friendliness, and so on.

Variables and Attributes

- Quality characteristics fall into two broad classes: **variables and attributes.**

- **Characteristics that are measurable and are expressed on a numerical scale are called variables.** The waiting time in a bank before being served, expressed in minutes, is a variable, as are the density of a liquid in grams per cubic centimeter and the resistance of a coil in ohms.

- **A quality characteristic is said to be an attribute if it is classified as either conforming or nonconforming to a stipulated specification.** A quality characteristic that cannot be measured on a numerical scale is expressed as an attribute. For example, the smell of a cologne is characterized as either acceptable or is not; the colour of a fabric is either acceptable or is not.

- However, there are some variables that are **treated as attributes because it is simpler to measure them this way** or because it is difficult to obtain data on them.

- Examples in this category are numerous. For instance, the diameter of a bearing is, in theory, a variable.

- However, if we measure the diameter **using a go/no-go gage and classify it as either conforming or nonconforming** (with respect to some established specifications), the characteristic is expressed as an attribute.

- The reasons for **using a go/no-go gage, as opposed to a micrometer, could be economic;** that is, the time needed to obtain a measurement using a go/no-go gage may be much shorter and consequently less expensive.

Defects and Standard/Specification

- A defect is associated with a quality characteristic that does not meet certain standards. The modern term for **defect is nonconformity**, and the term for **defective is nonconforming item**.

- A **standard, or a specification**, refers to a precise statement that formalizes the requirements of the customer; it may relate to a product, a process, or a service. For example, the specifications for an axle might be 2 ± 0.1 centimeters (cm) for the inside diameter, 4 ± 0.2 cm for the outside diameter, and 10 ± 0.5 cm for the length. This means that for an axle to be acceptable to the customer, each of these dimensions must be within the values specified.

Dimensions of Quality

Dimension	Description
Performance	It is the primary operating characteristics, which determines how the product or service performs the intended function.
Features	These are special features (secondary) that appeal to customers.
Durability	It is the time duration or amount of use before being replaced or repaired.
Reliability	Likelihood of breakdown, repair or expected time of fault-free operation.
Serviceability	Convenience and cost of repair and maintenance and related to ease in resolving the customer complaints.
Appearance	Look, taste, smell, sound or any other effect which is felt by human beings.

Dimensions of Quality

Dimension	Description
Uniformity	Limited variations among different products of same type.
Consistency and conformance	Conformance with standard, matching with documentation, being on-time etc.
Safety	Harmless from health and environment point of view
Time	Waiting time, completion time for a service
Customer service	After sales service, treatment received during or before sales
Compatibility	Compatibility of the products/services with existing or standard interfaces, peripherals or other attachments, power source etc.

Quality of Design

- Quality of design deals with the stringent conditions that a product or service must minimally possess to satisfy the requirements of the customer. It implies that the product or service must be designed to meet at least minimally the needs of the consumer.

- Generally speaking, the design should be the simplest and least expensive while still meeting customer's expectations.

- Quality of design is influenced by such factors as the **type of product**, **cost**, **profit policy of the firm**, **demand for product**, **availability of parts and materials**, and **product safety**.

Quality of Design

- For example, suppose that the quality level of the yield strength of steel cables desired by the customer is 100 kg/cm2 (kilograms per square centimeter).

- When designing such a cable, the parameters that influence the yield strength would be **selected so as to satisfy this requirement at least minimally.**

- In practice, **the product is typically overdesigned so that the desired conditions are exceeded.**

- **The choice of a safety factor (k) normally accomplishes this purpose.** Thus, to design a product with a 25% stronger load characteristic over the specified weight, the value of k would equal 1.25, and the product will be designed for a yield strength of 100 x 1.25 = 125 kg/cm2.

Quality of Design

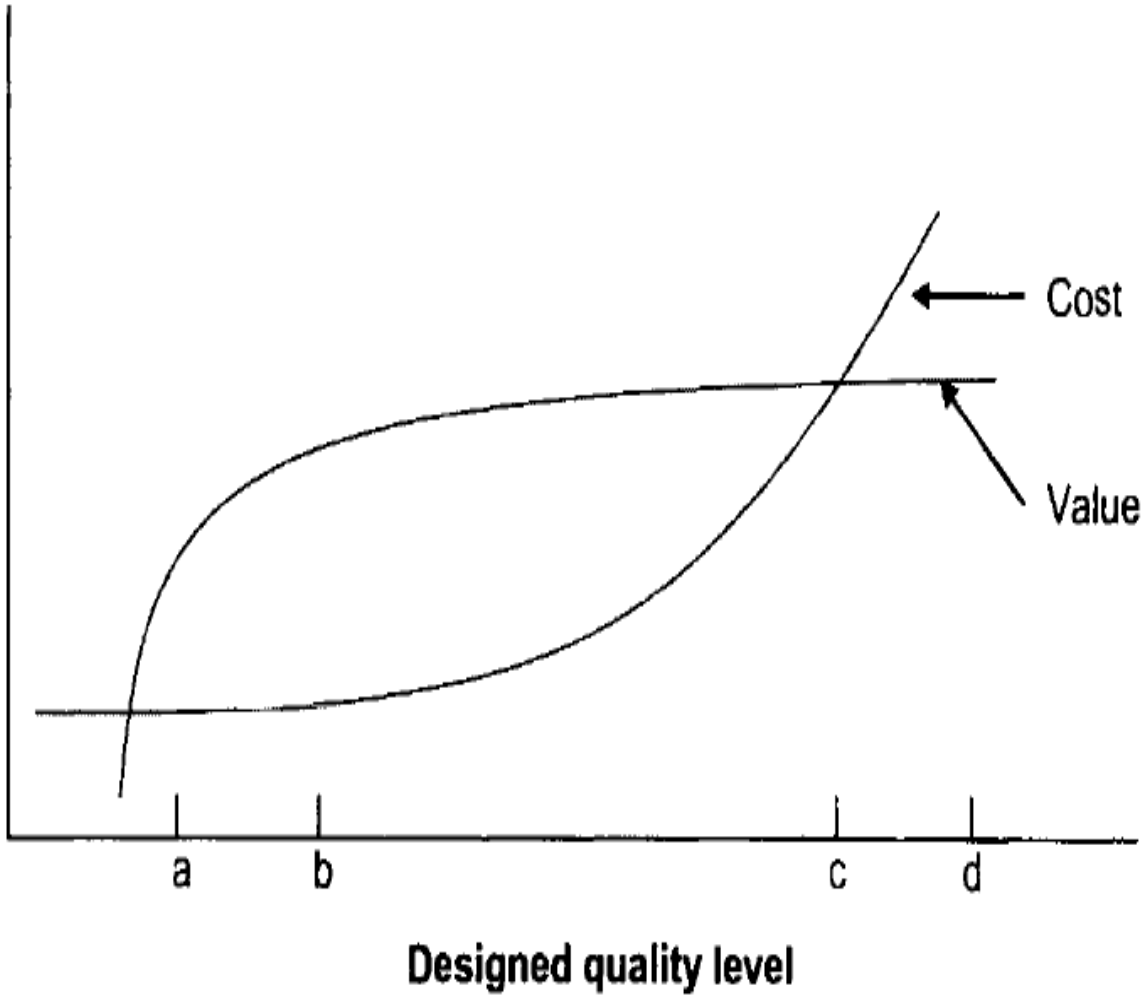

FIGURE 1-1 Cost and value as a function of designed quality.

Quality of Conformance

- Quality of conformance implies that a manufactured product or a service rendered must meet the standards selected in the design phase.

- With respect to the manufacturing sector, this phase is concerned with the degree to which **quality is controlled from the procurement of raw material to the shipment of finished goods.**

- It consists of the three broad areas of **defect prevention, defect finding, and defect analysis and rectification**. As the name suggests, **defect prevention** deals with the means to deter the occurrence of defects and is usually achieved using statistical process control techniques. **Locating defects** is conducted through inspection, testing, and statistical analysis of data from the process. **Finally, the causes behind the presence** of defects are investigated, and corrective actions are taken.

Quality of Performance

- Quality of performance is concerned with how well a product functions or service performs when put to use.

- It measures the degree to which the product or service satisfies the customer.

- This is a function of both the quality of design and the quality of conformance. Remember that the final test of product or service acceptance always lies with the customers. Meeting or exceeding their expectations is the major goal. If a product does not function well enough to meet these expectations, or if a service does not live up to customer standards, adjustments need to be made in the design or conformance phase.

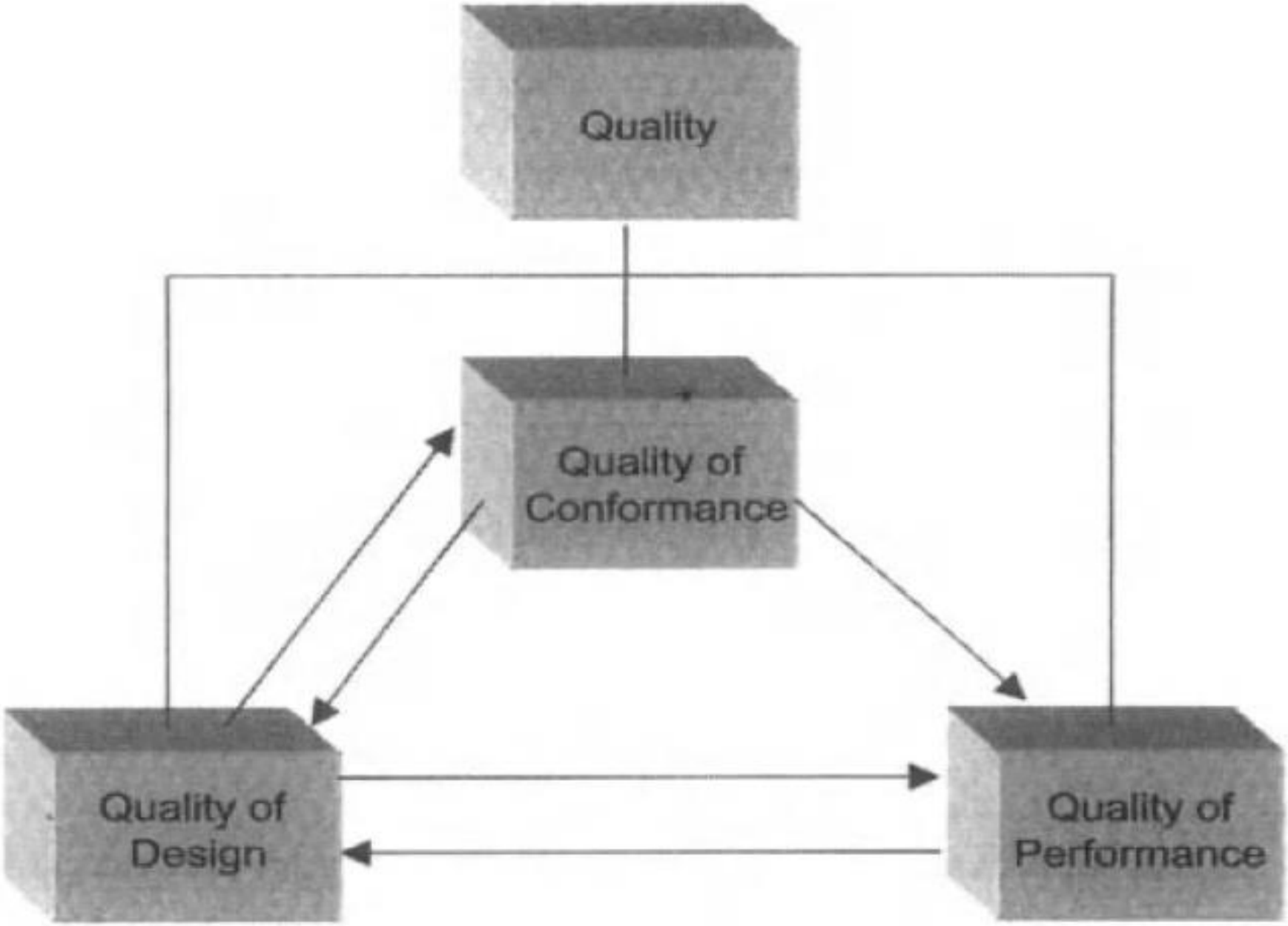

FIGURE 1-2 The three aspects of quality.

QUALITY COSTS

- **Prevention Costs:**

  - They are incurred in planning, implementing, and maintaining a quality system to prevent poor quality in products and services.

  - They include salaries and developmental costs for product design, process and equipment design, process control techniques (through such means as control charts), information systems design, and all other costs associated with making the **product right the first time.**

- Also, costs associated with education and training are included in this category.

- Other such costs include those associated with defect cause and removal, process changes, and the cost of a quality audit.

- Prevention costs increase with the introduction of a quality system and, initially, may be a significant proportion of the total quality costs.

Prevention Cost	
Quality planning QC administration and system planning Quality related training Inspection of incoming, in-process and final products Monitoring of processes Design review Quality data analysis	Procurement planning Market research Vendor survey Reliability studies System development Quality measurement and control Product qualification Qualification of materials

- **Appraisal Costs:**

  - They are those costs associated with measuring, evaluating, or auditing products, components, purchased materials, or services to determine their degree of conformance to the specified standards.

  - Such costs include dealing with the inspection and testing of incoming materials as well as product inspection and testing at various phases of manufacturing and at final acceptance.

  - Other costs in this category include the **cost of calibrating and maintaining measuring instruments** and equipment and the **cost of materials and products consumed in a destructive test** or devalued by reliability tests.

Appraisal costs	
Incoming inspection Testing Inspection in process Quality audits Incoming tests and laboratory test Checking labour Laboratory or other measurement service Setup for test and inspection	Test and inspection material Outside endorsements for certification Maintenance and calibration work Product engineering review and shipping Field testing Final testing

- **Internal Failure Costs:-**

  - These are the costs that are incurred when products, components, materials, and services **fail to meet quality requirements prior to the transfer of ownership to the customer.**

  - These costs would disappear if there were no nonconformities in the product or service.

  - Internal failure costs include **scrap and rework costs** for the materials, labor, and overhead associated with production.

- The **cost of correcting nonconforming** units, as in rework, can include such additional manufacturing operations **as regrinding the outside diameter** of an oversized part.

- The costs **involved in determining the cause of failure or in reinspecting or retesting reworked** products are other examples from this category.

Internal failure costs	
Rejection Scrap at full shop cost Rework at full shop cost Failure analysis Scrap and rework, fault of vendor Material procurement Excess inventory	Factory contact engineering Machine down QC investigations of failures Material review activity Repair and troubleshooting

- **External Failure Costs:**

  - External failure costs are incurred when a product does not perform satisfactorily after ownership is transferred to the customer or services offered are nonconforming.

  - If no nonconforming units were produced, this cost would vanish.

  - Such costs include those due to customer complaints, which include the **costs of investigation and adjustments, and those associated with receipt, handling, repair, and replacement of nonconforming products.**

  - **Warranty charges** (failure of a product within the warranty time) and **product liability costs** (costs or awards as an outcome of product liability litigation) also fall under this category.

External failure costs	
Recalls Complaints handling Goodwill loss Warranty costs Bad publicity Field maintenance and product service	Returned material processing and repair Fall in marker share Replacement inventories Low employee morale Strained distributor relations

Hidden Failure Costs

- The measurable components of failure costs include those associated with scrap, rework, or warranty, which are easily tracked by accounting systems.

- A significant segment of the failure costs are **"hidden." These include management and engineering time associated** with cause identification and determination of remedial actions associated with failures.

- **Line downtime, the necessity to carry increased inventory, the decrease in available capacity, and orders lost due to poor quality** are examples of costs not easily tracked by accounting systems.

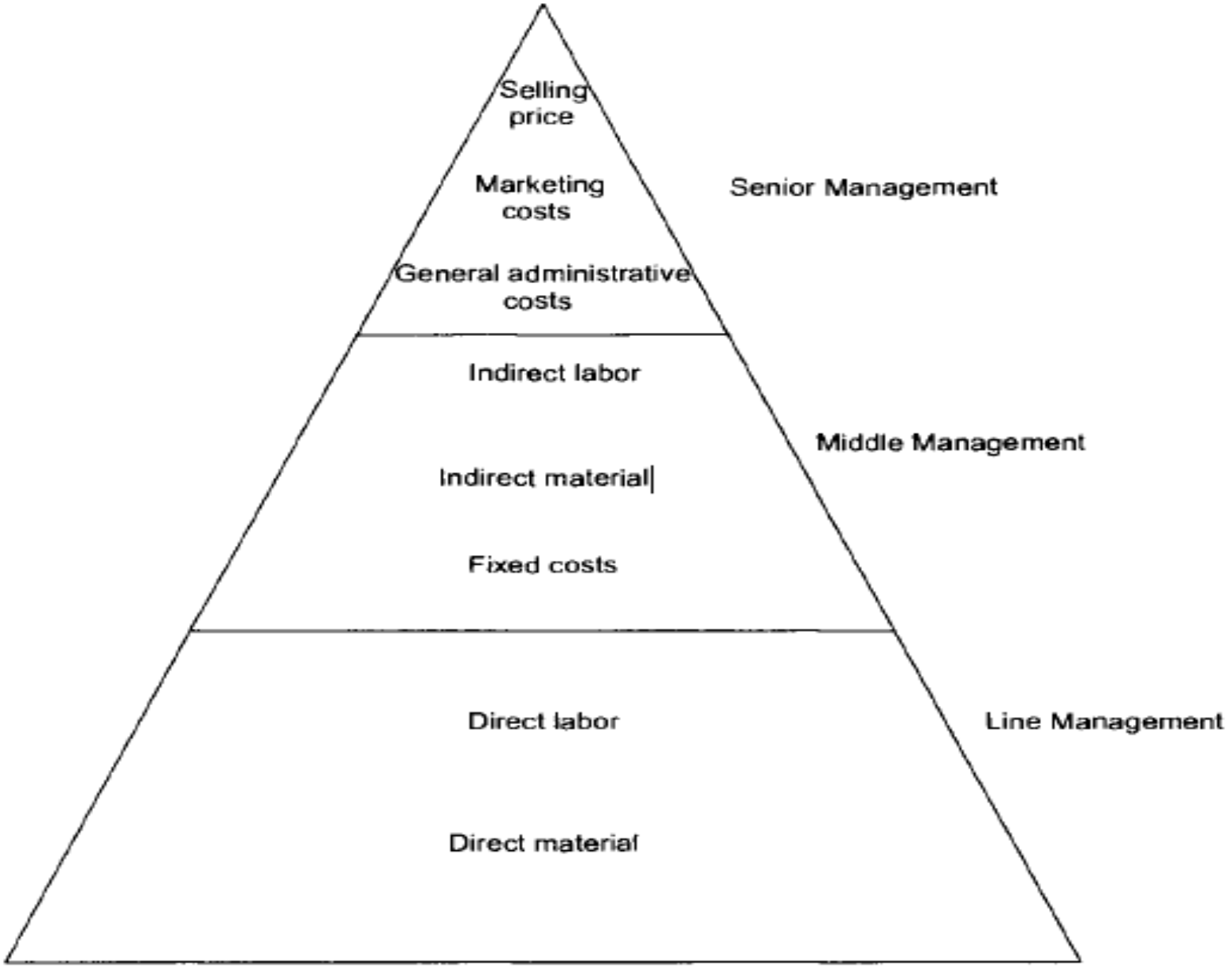

FIGURE 1-4 Quality costs data requirements at different management levels.

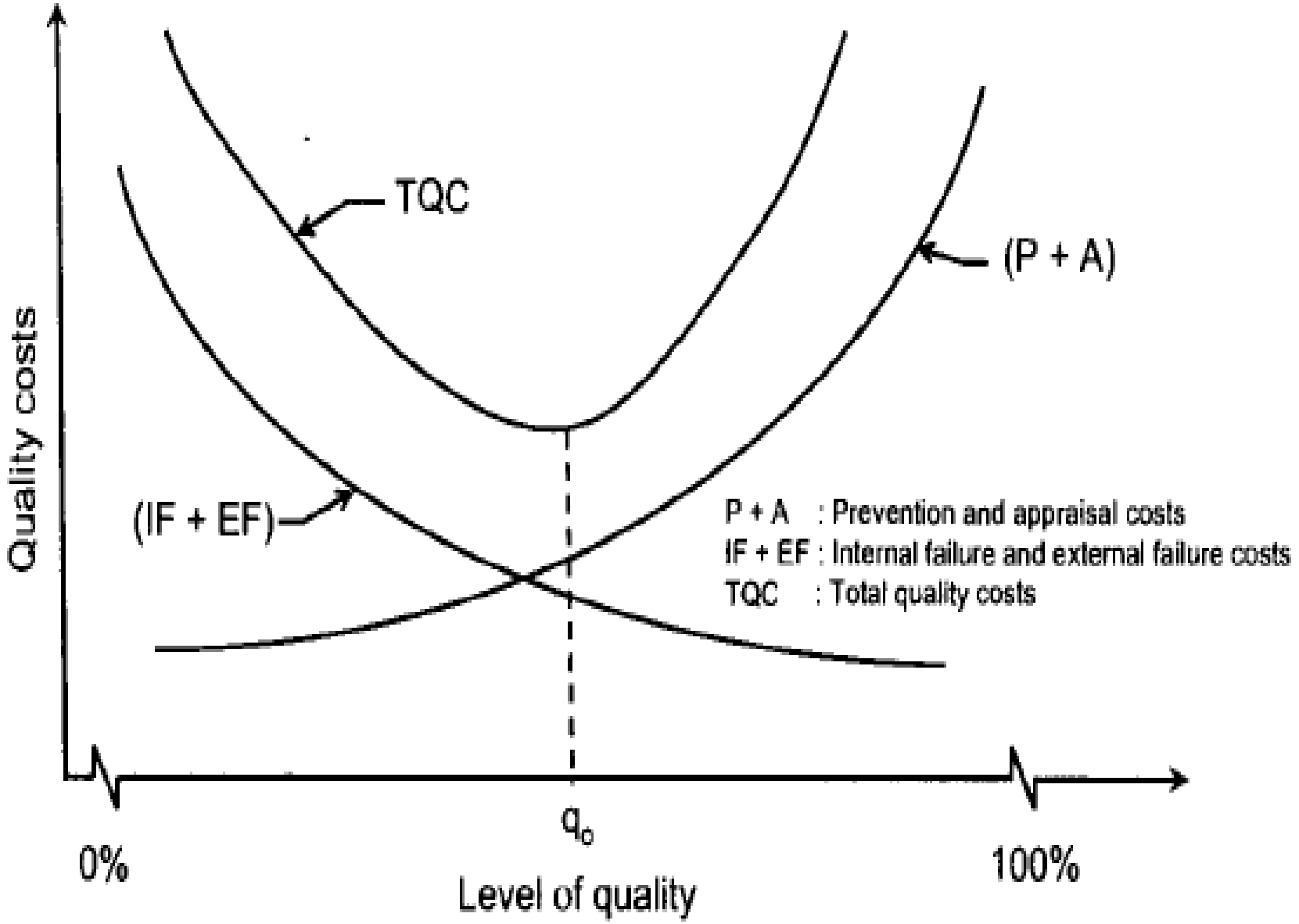

FIGURE 1-5 Quality costs versus level of quality.

QUALITY CONTROL

- Quality control may generally be defined as a **system that maintains a desired level of quality, through feedback on product/service characteristics and implementation of remedial actions,** in case of a deviation of such characteristics from a specified standard.

- This general area may be divided into three main subareas: **off-line quality control, statistical process control, and acceptance sampling plans**.

- **Off-Line Quality Control:**

  - **Off-line quality control procedures deal with measures to select and choose controllable product and process parameters** in such a way that the deviation between the product or process output and the standard will be minimized.

  - **Much of this task is accomplished through product and process design. The goal is to come up with a design within the constraints of resources and environmental parameters** such that when production takes place, the output meets the standard. Thus, to the extent possible, the product and process parameters are set before production begins.

- **Statistical Process Control**

- *Statistical process control involves* ***comparing the output of a process or service with a*** **standard and taking remedial actions in case of a discrepancy** between the two.

- It also involves determining whether a process can produce a product that meets desired specifications or requirements.

- For example, to control paperwork errors in an administrative department, information might be gathered daily on the number of errors. If the number observed exceeds a specified standard, then on identification of possible causes, action should be taken to reduce the number of errors.

- **Acceptance Sampling Plans**

- Acceptance sampling plans involve inspection of a product or service. When 100% inspection of all items is not feasible, a decision has to be made as to how many items should be sampled or whether the batch should be sampled at all.

- The information obtained from the sample is used to decide whether to accept or reject the entire batch or lot.

- In the case of attributes, one parameter is the acceptable number of nonconforming items in the sample. If the number of nonconforming items observed is less than or equal to this number, the batch is accepted. This is known as the *acceptance number.*

- A **plan that determines the number of items to sample and the acceptance criteria** of the lot, based on meeting certain stipulated conditions (such as the risk of rejecting a good lot or accepting a bad lot), is known as an acceptance sampling plan.

QUALITY ASSURANCE

- The objective of the quality assurance function is to have in place a formal system that continually surveys the effectiveness of the quality philosophy of the company.

- The quality assurance team thus audits the various departments and assists them in meeting their responsibilities for producing a quality product.

- Quality assurance may be conducted, for example, at the product design level by surveying the procedures used in design. An audit may be carried out to determine the type of information that should be generated in the marketing department for use in designing the product.

- Is this information representative of the customer's requirements?
- If one of the customer's key needs in a food wrap is that it withstand a certain amount of force, is that information incorporated in the design?
- Do the data collected represent that information? How frequently are the data updated?
- Are the forms and procedures used to calculate the withstanding force adequate and proper?
- Are the measuring instruments calibrated and accurate? Does the design provide a safety margin?

QUALITY CIRCLES

- **A quality circle is typically an informal group of people that consists of operators,** supervisors, managers, and so on, who get together to improve ways to make a product or deliver a service.

- The concept behind quality circles is that in most cases, the persons who are **closest to an operation** are in a better position to contribute ideas that will lead to an improvement in it.

- Thus, **improvement-seeking ideas do not come only from managers** but also from all other personnel who are involved in the particular activity.

- A quality circle tries to overcome barriers that may exist within the prevailing organizational structure so as to **foster an open exchange of ideas.**

QUALITY IMPROVEMENT TEAMS

- A **quality improvement team is another means of identifying feasible solutions to** quality control problems.

- Such teams are typically **cross-functional in nature** and involve people from various disciplines.

- It is not uncommon to have a quality improvement team with personnel from **design and development, engineering, manufacturing, marketing, and servicing**.

- A key advantage of such a team is that it promotes **cross-disciplinary flow of information in real time** as it solves the problem.

- When design changes are made, then feasibility of **equipment and tools in meeting the new requirements must be analyzed.**

- It is thus essential for information to flow between design, engineering, and manufacturing.

- Furthermore, the product must be analyzed from the perspective of meeting customer needs.

- Do the new design changes satisfy the unmet needs of customers?

- What are typical customer complaints regarding the product? **Including personnel from marketing and servicing** on these teams assists in answering these questions.

CUSTOMER NEEDS AND MARKET SHARE

- **Kano Model:** Noriaki Kano, a Japanese consultant, developed a model relating design characteristics to customer satisfaction.

- Customer needs or expectations can be divided into three prioritized categories: **basic needs (dissatisfiers); performance needs (satisfiers); and excitement needs (delighters).**

- Basic needs **are those that are taken for granted by the customer.** Meeting these needs may not steeply increase customer satisfaction; but not meeting them will definitely cause dissatisfaction. For example, in a city public library, it is taken for granted that current editions of popular magazines will be available. Not having them will lead to dissatisfied consumers.

- **Performance needs** are those that the consumer expects. Thus, the better these are met, the more satisfied the customer.

- Typically, **customer satisfaction increases as a linear function of the degree to which such needs are met**. Ease of checking out a book or video at a city library could be one such need.

- **Excitement needs, also known as delighters, are those that surprise the customer unexpectedly**. The consumer does not necessarily expect these and hence may not express them.

- So, when they are met, **it increases customer satisfaction in an exponential manner.** For example, if the city library offered free consultation on tax-form preparation, customers might be delighted beyond bounds.

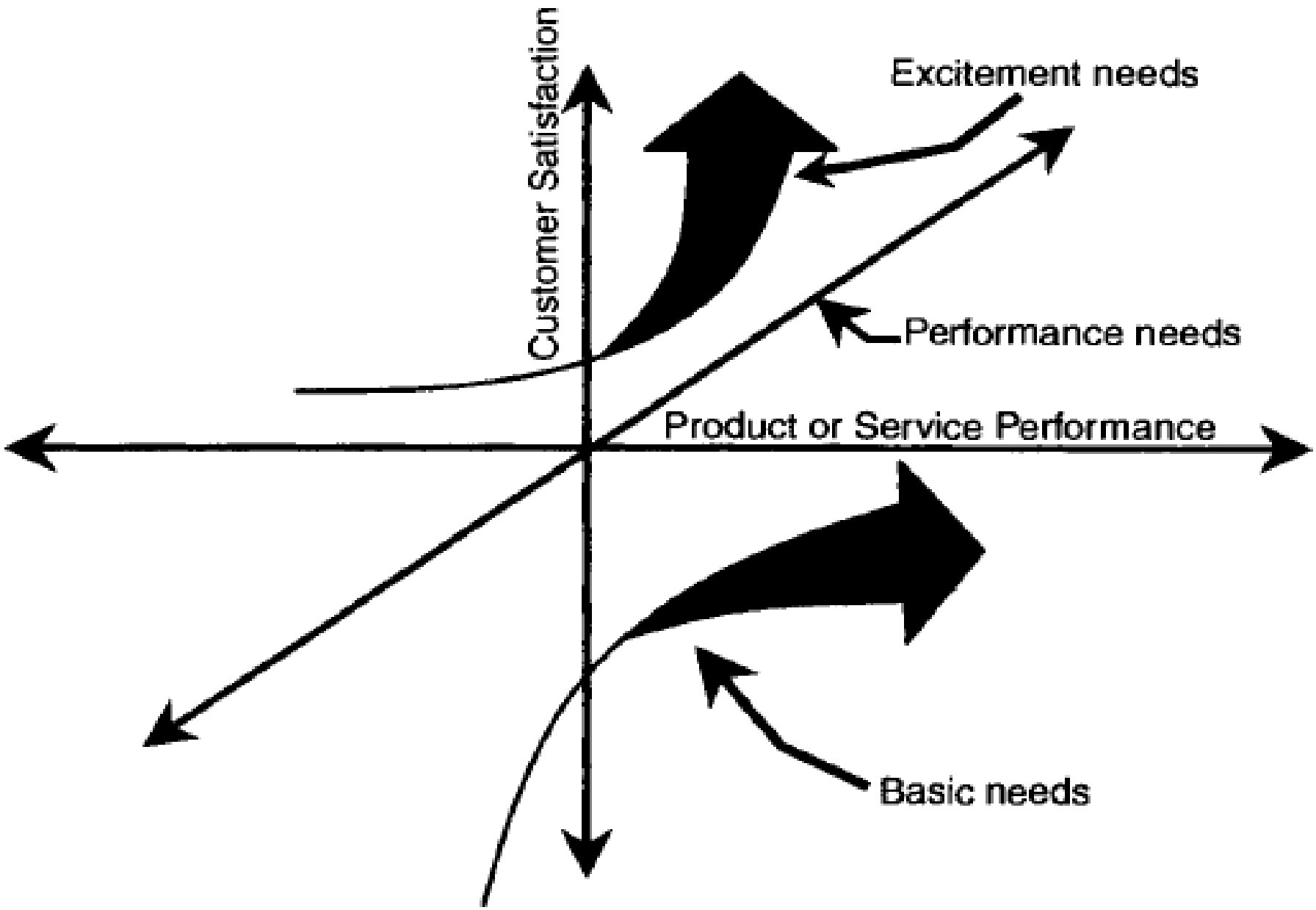

FIGURE 1-3 Kano model.

BENEFITS OF QUALITY CONTROL

- First and foremost is the **improvement in the quality of products and services.** Production improves because a well-defined structure for achieving production goals is present.

- Second, the system is **continually evaluated and modified to meet the changing needs of the customer**. Therefore, a mechanism exists for rapid modification of product or process design, manufacture, and service to meet customer requirements so that the company remains competitive.

- Third, a **quality control system improves productivity, which is a goal of every organization**. It reduces the production of scrap and rework, thereby increasing the number of usable products.

- Fourth, **such a system reduces costs in the long run.** The notion that improved productivity and cost reduction do not go hand in hand is a myth. On the contrary, this is precisely what a quality control system does achieve. With the production of **few nonconforming items, total costs decrease, which may lead to a reduced selling price and thus increased competitiveness**.

- Fifth, with **improved productivity, the lead time for producing parts and subassemblies is reduced**, which results in **improved delivery dates**. One again, quality control keeps customers satisfied. Meeting or exceeding their needs on a timely basis helps sustain a good relationship.

- Last, but not least, a quality control system maintains an **"improvement" environment where everyone strives for improved quality and productivity**.

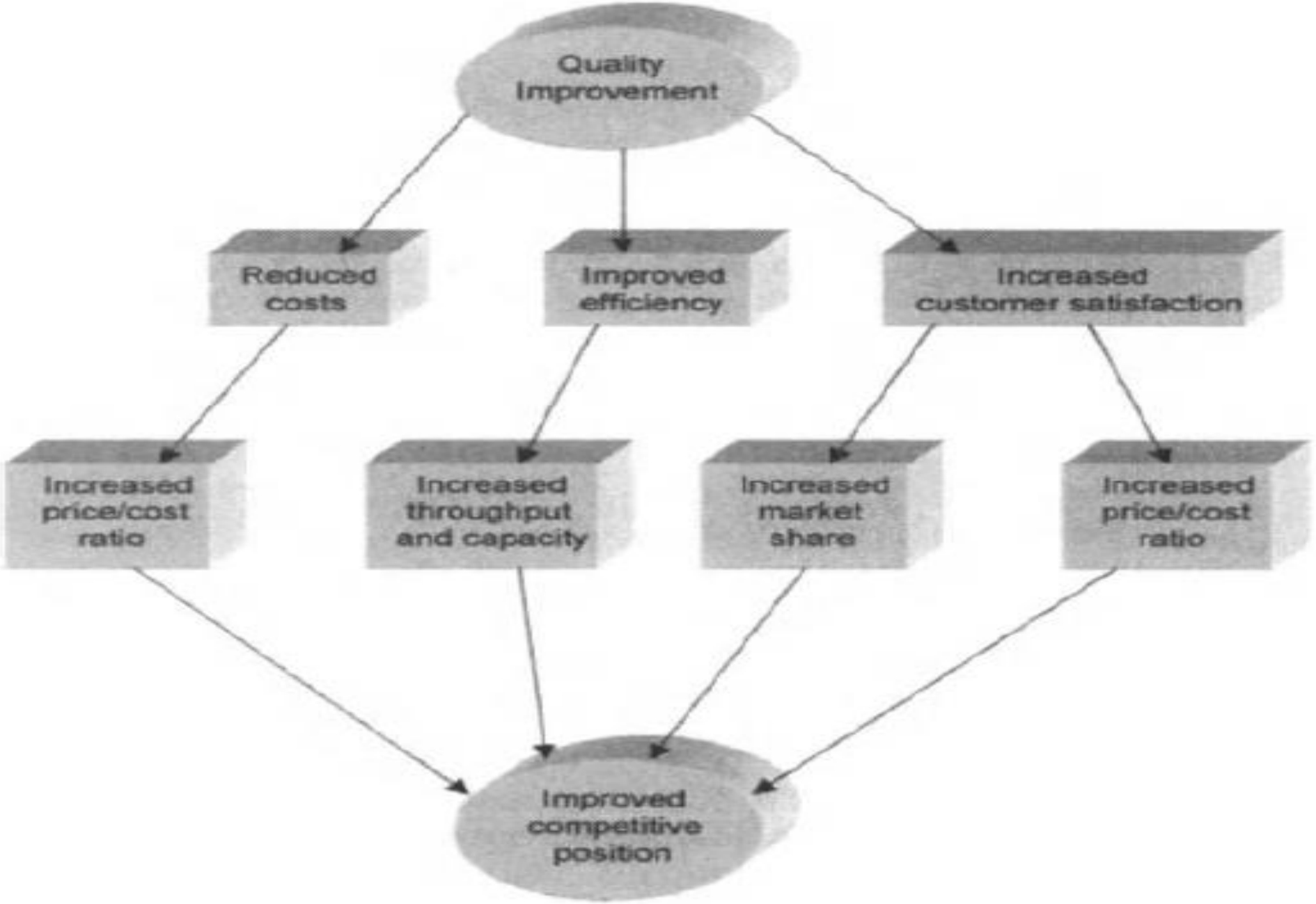

FIGURE 1-11 Impact of quality on competitive position.

Customers' view – Requirement and assessment