Quality

Learning Objectives

- **Quality:**
  - Definition
  - Dimensions
  - Determinants
  - Cost
  - Impact

What is Quality?

- Conformance to specifications
- Fitness for use
- Value for price paid

- $Q = P/E$
- Q = Quality
- P = Performance
- E = Expectations

What is Quality?

"*The quality of a product or service is a customer's perception of the degree to which the product or service meets his or her expectations.*"

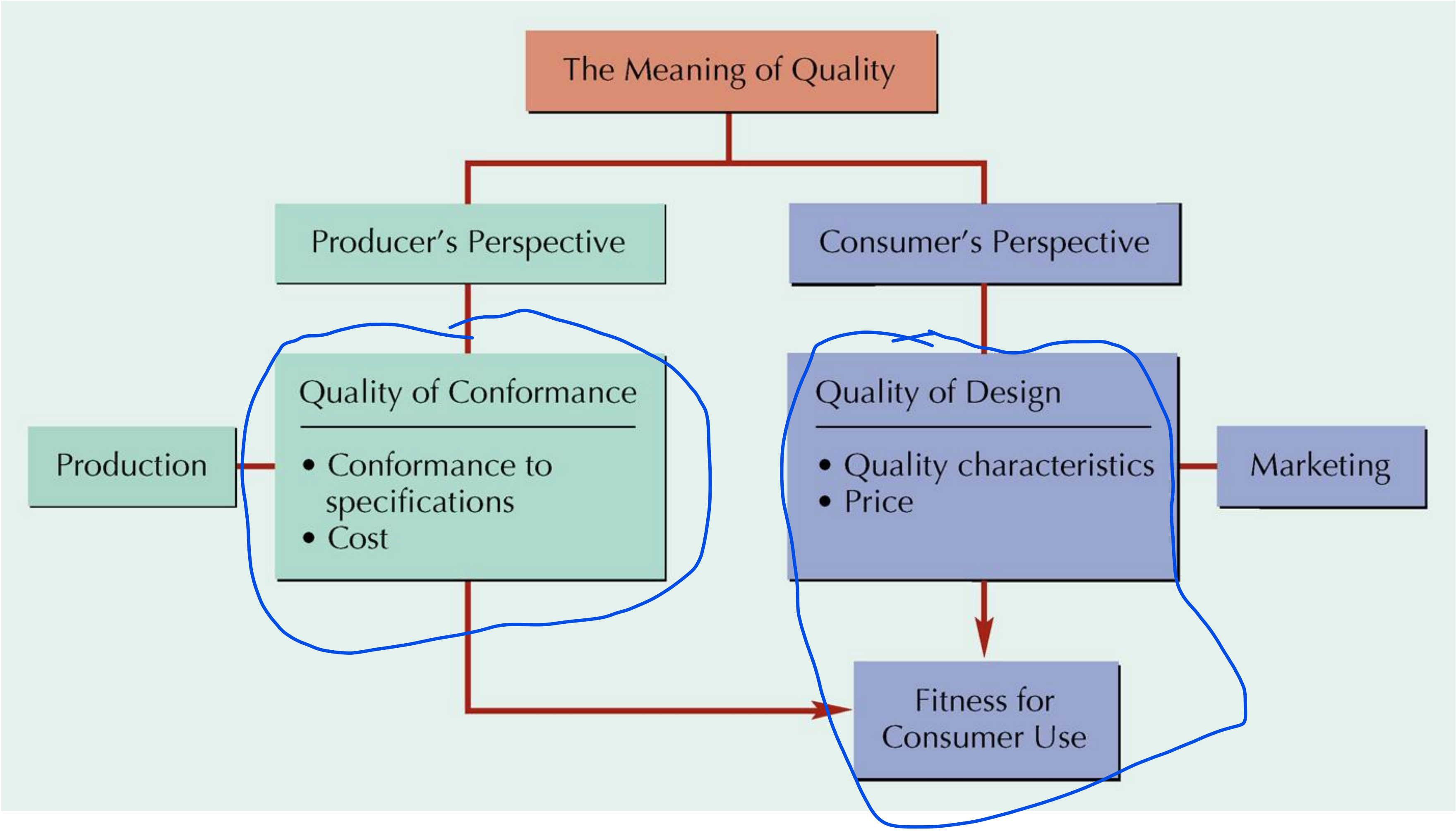
Nature of Quality

- Dimensions of Quality
- Determinants of Quality
- Costs of Quality

Some Dimensions of Product Quality

- Performance – primary characteristics (signal to noise ratio, power - time to process customer requests)
- Features – secondary characteristics, special characteristics (remote control)
- Reliability – Consistency of performance over time. (MTTF,MTBF,breakdowns, malfunctions)
- Serviceability – Ease of repair. (speed/cost/convenience of servicing)

- **Durability** – useful life amount of time/use before repairs
- **Appearance** – aesthetics, effects on human senses
- **Customer service** – treatment before/during/after sale
- **Safety** – user protection before/during/after use


The Meaning of Quality
Producer's Perspective
Consumer's Perspective
Production
Quality of Conformance
• Conformance to specifications
• Cost
Quality of Design
• Quality characteristics
• Price
Marketing
Fitness for Consumer Use

- Customer’s and producer’s perspectives depend on each other
- Producer’s perspective:
  - production process and COST
- Customer’s perspective:
  - fitness for use and PRICE
- Customer’s view must dominate

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    - **Determinants**
    - **Cost**
    - Impact

Determinants of Quality

- Quality of design – products/service designed based on customers' expectations and desires.
- Quality capability of production processes – processes must be capable of producing the products designed for the customers (surface finish in microns : m/cs. Tools. Measuring equipment)
- Quality of conformance – refers to the degree to which the product or service design specifications are met. (capable processes can produce inferior product if not operated properly.
- Quality of customer service – a superior product does not mean success; must have quality service also
- Organization quality culture – superior product and service requires organization-wide focus on quality

Costs of Quality

- <u>Scrap and rework</u> - rescheduling, repairing, retesting

- <u>Defective products in the hands of the customer</u> - recalls, warranty claims, due to awareness - law suits, lost business, …

- <u>Detecting defects</u> - inspection, testing, ….

- <u>Preventing defects</u> - training, charting performance,

- Product/process redesign, supplier development, ….

Cost of Quality

- Cost of Achieving Good Quality
  - Prevention costs
    - costs incurred during product design
  - Appraisal costs
    - costs of measuring, testing, and analyzing
- Cost of Poor Quality
  - Internal failure costs
    - include scrap, rework, process failure, downtime, and price reductions
  - External failure costs
    - include complaints, returns, warranty claims, liability, and lost sales

Prevention Costs

- Quality planning costs
  - costs of developing and implementing quality management program
- Product-design costs
  - costs of designing products with quality characteristics
- Process costs
  - costs expended to make sure productive process conforms to quality specifications
- Training costs
  - costs of developing and putting on quality training programs for employees and management
- Information costs
  - costs of acquiring and maintaining data related to quality, and development and analysis of reports on quality performance

Appraisal Costs

- Inspection and testing
  - costs of testing and inspecting materials, parts, and product at various stages and at end of process
- Test equipment costs
  - costs of maintaining equipment used in testing quality characteristics of products
- Operator costs
  - costs of 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

Internal Failure Costs

- Scrap costs
  - costs of poor-quality products that must be discarded, including labor, material, and indirect costs
- Rework costs
  - costs of fixing defective products to conform to quality specifications
- Process failure costs
  - costs of determining why production process is producing poor-quality products
- Process downtime costs
  - costs of shutting down productive process to fix problem
- Price-downgrading costs
  - costs of discounting poor-quality products—that is, selling products as “seconds”

External Failure Costs

- Customer complaint costs
  - costs of investigating and satisfactorily responding to a customer complaint resulting from a poor-quality product
- Product return costs
  - costs of handling and replacing poor-quality products returned by customer
- Warranty claims costs
  - costs of complying with product warranties

- Product liability costs
  - litigation costs resulting from product liability and customer injury
- Lost sales costs
  - costs incurred because customers are dissatisfied with poor-quality products and do not make additional purchases

Cost of Quality

Cost of achieving good quality

- Appraisal
- Prevention

Cost of poor quality

- Internal failure
- External failure

Learning Objectives

- **Quality:**
    - Definition
    - Dimensions
    - Determinants
    - Cost
    - **Impact**

Do O&SCM and QM practices create an impact?

- Impact on the
  - Organization
  - Customers
  - Society

Analysis and Use of Quality Costs (example)

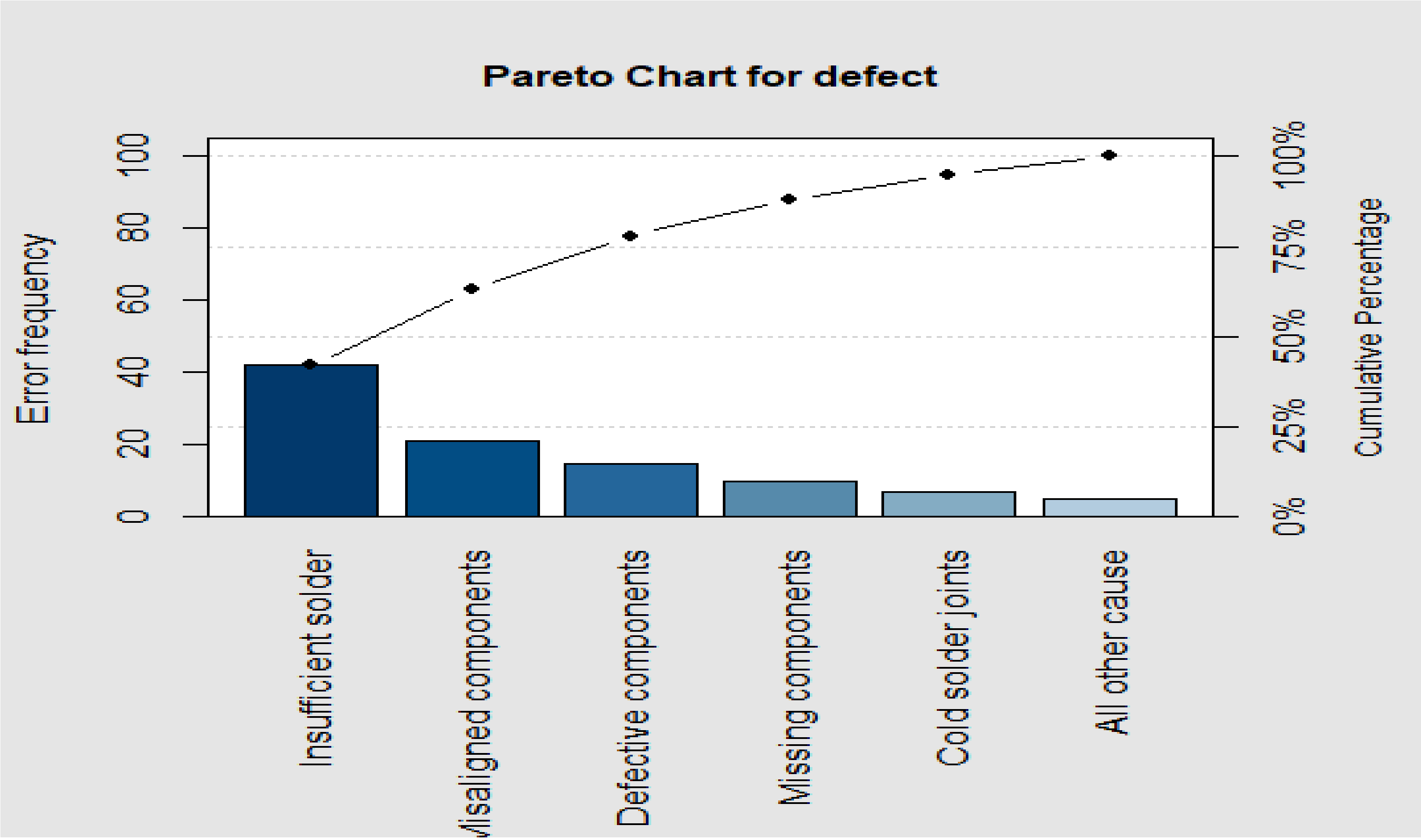
Table 1.3

Monthly Quality-Costs Information for Assembly of Printed Circuit Boards

Type of Defect	Percent of Total Defects	Scrap and Rework Costs
Insufficient solder	42	$37,500.00 (52%)
Misaligned components	21	12,000.00
Defective components	15	8,000.00
Missing components	10	5,100.00
Cold solder joints	7	5,000.00
All other causes	5	4,600.00
Totals	100%	$72,200.00

Quality costs

- Leverage effect
- Pareto analysis



Quality and efficiency/productivity

- Efficiency = Output/Input
- Leverage effect: Quality improvements more than pay for themselves

- Illustration:
  - Consider the manufacture of a mechanical component used in an assembly.
  - Parts are manufactured in a process at a rate of approximately 100 parts per day.
  - First-pass yield = 70% (conforming).
  - 70% of the fallout (the 30% nonconforming) can be reworked into an acceptable product, and the rest must be scrapped.

Quality and efficiency/productivity

- The direct manufacturing cost = ₹30/part.
- Reworked parts incur an additional processing charge = ₹6

Cost / good part = ?

Total Yield after rework = ?

Quality and efficiency/productivity

- The direct manufacturing cost = ₹30/part.
- Reworked parts incur an additional processing charge = ₹6

Cost / good part = ((₹30*100) + (₹6*21))/91 = ₹ 34.35

Total Yield after rework = 91 good parts / day

Quality and efficiency/productivity

- Quality management procedures reduce the variability and thereby process fallout from 30% to 5%.

- Of the 5% fallout produced, about 70% can be reworked & 30% are scrapped

  Cost / good part = ?

  Total Yield after rework = ?

- Quality management led to
  - ?% reduction in manufacturing costs
  - ?% increase in productivity

Quality and efficiency/productivity

- Quality management procedures reduce the variability and thereby process fallout from 30% to 5%.

- Of the 5% fallout produced, about 70% can be reworked & 30% are scrapped

  Cost / good part = ((₹30*100) + (₹6*3.5))/98.5 = ₹30.67

  Total Yield after rework = 98.5 good parts / day

- Quality management led to
  - 10.7% reduction in manufacturing costs
  - 8.2% increase in productivity

Quality and efficiency/productivity

- Typical cost of deploying quality management procedures (Cost of doing things right)
  - 3-4 % of revenues

- Cost of doing things wrong
  - 20-35% of revenues

Quality–Cost Relationship

- Cost of quality
  - difference between price of nonconformance and conformance
  - cost of doing things wrong
    - 20 to 35% of revenues
  - cost of doing things right
    - 3 to 4% of revenues

Measuring Product Yield and Productivity

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

or

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

where

I = initial quantity started in production

%G = percentage of good units produced

%R = percentage of defective units that are successfully reworked

Computing Product Yield

- Motor manufacturer
- Starts a batch of 100 motors.
- 80 % are good when produced
- 50 % of the defective motors can be reworked

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

$=$

Increase quality to 90% good

Y $=$

Computing Product Yield

- Motor manufacturer
- Starts a batch of 100 motors.
- 80 % are good when produced
- 50 % of the defective motors can be reworked

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

= 100(.80) + 100(1-.80)(.50) = 90 motors

Increase quality to 90% good

Y =100(.90) + 100(1-.90)(.50) = 95 motors

Computing Product Cost per Unit

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

where:

K_d = direct manufacturing cost per unit

I = input

K_r = rework cost per unit

R = reworked units

Y = yield

Cost per Unit

Direct cost = $30

80% good

Rework cost = $12

50% can be reworked

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

Increase quality to 90% good

Cost per Unit

Direct cost = $30

80% good

Rework cost = $12

50% can be reworked

$$\frac{(K_d)(I) + (K_r)(R)}{Y} = \frac{\$30*100 + \$12*10}{90 \text{ motors}} = \$34.67/\text{motor}$$

Increase quality to 90% good

$$= \frac{\$30*100 + \$12*5}{95 \text{ motors}} = \$32.21/\text{motor}$$

Computing Product Yield for Multistage Processes

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

where:
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

Multistage Yield

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

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

Multistage Yield

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

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

$$= 100 * .93 * .95 * .97 * .92 = 78.8 \text{ motors}$$

Initial Batch Size For 100 Motors

$$I = \frac{Y}{(\%g_1)(\%g_2)\ \dots\ (\%g_n)}$$

Initial Batch Size For 100 Motors

$$I = \frac{Y}{(\%g_1)(\%g_2)\ \dots\ (\%g_n)}$$

$$= \frac{100}{\cancel{100} * .93 * .95 * .97 * .92} = 126.88 \rightarrow 127$$

Quality–Productivity Ratio

QPR

- productivity index that includes productivity and quality costs

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

Quality Productivity Ratio

Direct cost = $30

80% good

Initial batch size = 100

Rework cost = $12

50% can be reworked

Base Case

QPR =

Case 1: Increase I to 200

QPR =

Quality Productivity Ratio

Case 2: Reduce direct cost to \$26 and rework cost to \$10

QPR =

Case 3: Increase %G to 95%

QPR =

Case 4: Decrease costs and increase %G

QPR =

Quality Productivity Ratio

Direct cost = $30

80% good

Initial batch size = 100

Rework cost = $12

50% can be reworked

Base Case

$$QPR = \frac{80 + 10}{100 * \$30 + 10 * \$12}(100) = 2.89$$

Case 1: Increase I to 200

$$QPR = \frac{160 + 20}{200 * \$30 + 20 * \$12}(100) = 2.89 \text{ – NO CHANGE}$$

Quality Productivity Ratio

Case 2: Reduce direct cost to $26 and rework cost to $10

$$QPR = \frac{80 + 10}{100 * \$26 + 10 * \$10} (100) = 3.33$$

Case 3: Increase %G to 95%

$$QPR = \frac{95 + 2.5}{100 * \$30 + 2.5 * \$12} (100) = 3.22$$

Case 4: Decrease costs and increase %G

$$QPR = \frac{95 + 2.5}{100 * \$26 + 2.5 * \$10} (100) = 3.71$$