Stevenson 5

Capacity Planning

Learning Objectives

- Explain the importance of capacity planning.
- Describe the determinants of effective capacity.
- Discuss the major considerations related to developing capacity alternatives.
- Briefly describe approaches that are useful for evaluating capacity alternatives

Capacity Planning

- Capacity is the upper limit or ceiling on the load that an operating unit can handle.
- Capacity also includes
  - Equipment
  - Space
  - Employee skills
- The basic questions in capacity handling are:
  - What kind of capacity is needed?
  - How much is needed?
  - When is it needed?

Strategic Capacity Planning

- Balancing of long term supply capabilities and predicted level of long term demand.
  - Forecasts are a key input.
    - Changes in demand
    - Changes in technology
    - Changes in the environment
    - Perceived threats and opportunities

Capacity Planning Considerations

- Cost, availability of funds, expected returns
- Potential benefits and risks.
  - Degree of uncertainty in forecasts.
- Sustainability issues.
- Rate of capacity addition?
  - All at once?
  - Incremental (piecemeal)?
- Timing of capacity addition?
  - Leading, following, or tracking?
- Supply chain support?

Importance of Capacity Decisions

1. Impacts ability to meet future demands
2. Affects operating costs
3. Major determinant of initial costs
4. Involves long-term commitment
5. Affects competitiveness (can be a barrier to deter potential new entry)
6. Globalization adds complexity
7. Impacts long range planning

Capacity

- Design capacity
  - maximum output rate or service capacity an operation, process, or facility is designed for
- Effective capacity
  - Design capacity minus allowances such as personal time, maintenance, and scrap
- Actual output
  - rate of output actually achieved--cannot exceed effective capacity.

Efficiency and Utilization

$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}}$$

$$\text{Utilization} = \frac{\text{Actual output}}{\text{Design capacity}}$$

Both measures expressed as percentages

Efficiency/Utilization Example

Design capacity = 50 trucks/day

Effective capacity = 40 trucks/day

Actual output = 36 units/day

$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}} = \frac{36 \text{ units/day}}{40 \text{ units/ day}} = 90\%$$

$$\text{Utilization} = \frac{\text{Actual output}}{\text{Design capacity}} = \frac{36 \text{ units/day}}{50 \text{ units/day}} = 72\%$$

Capacity Utilization Strategy

Key to improving capacity utilization is to increase effective capacity by correcting quality problems, maintaining equipment in good operating condition, fully training employees, and fully utilizing bottleneck equipment.

Steps for Capacity Planning

1. Estimate future capacity requirements
2. Evaluate existing capacity
3. Identify alternatives
4. Conduct financial analysis
5. Assess key qualitative issues
6. Select one alternative
7. Implement alternative chosen
8. Monitor results

Capacity planning can be difficult at times due to the complex influence of market forces and technology.

Planning Service Capacity

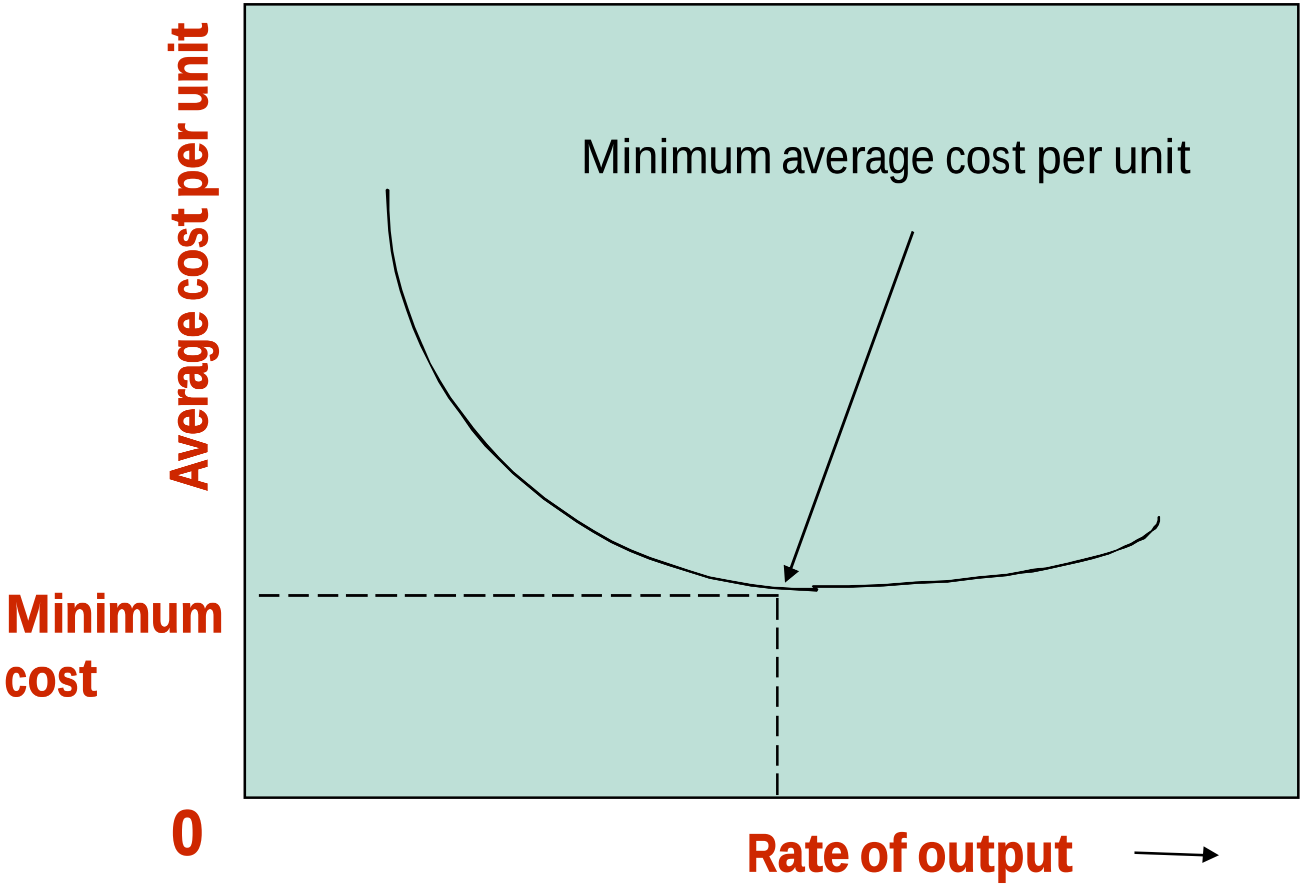
- Need to be near customers
  - Capacity and location are closely tied
- Inability to store services
  - Capacity must be matched with timing of demand
- Degree of volatility of demand
  - Peak demand periods

Economies of Scale

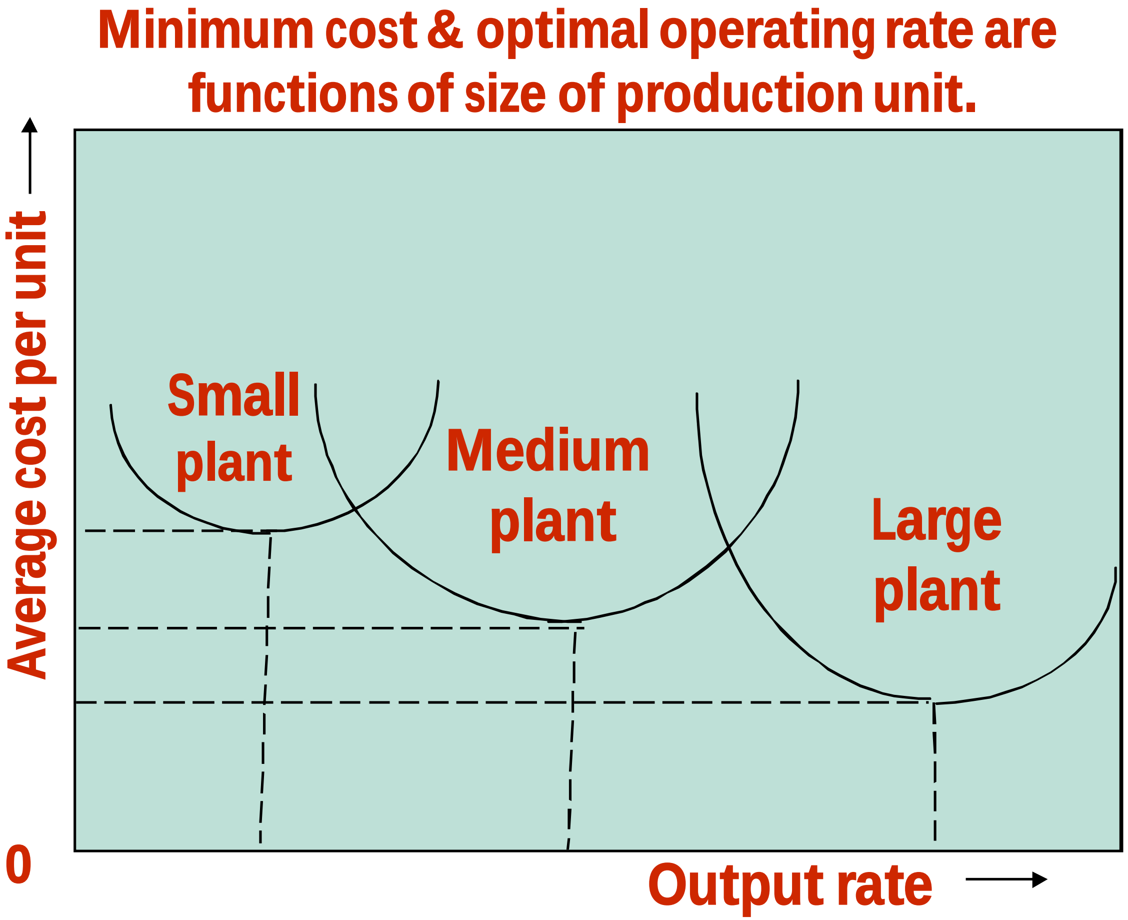
- Economies of scale
  - If the output rate is less than the optimal level, increasing output rate results in decreasing average unit costs
- Diseconomies of scale
  - If the output rate is more than the optimal level, increasing the output rate results in increasing average unit costs

Optimal Rate of Output

Production units have an optimal rate of output for minimal cost.



Economies of Scale



Factors contributing to Economies of Scale

- Fixed costs and spread over more units (products or customers), reducing the fixed cost per unit
- Construction costs increase at a decreasing rate with respect to the size of the facility
- Processing costs decrease as output increases because operations become more standardized (over time) which reduces unit costs

Evaluating Alternatives

- **Cost-volume analysis**
  - Break-even point
- Financial analysis
  - Cash flow
  - Present value
- Decision theory
- Waiting-line analysis

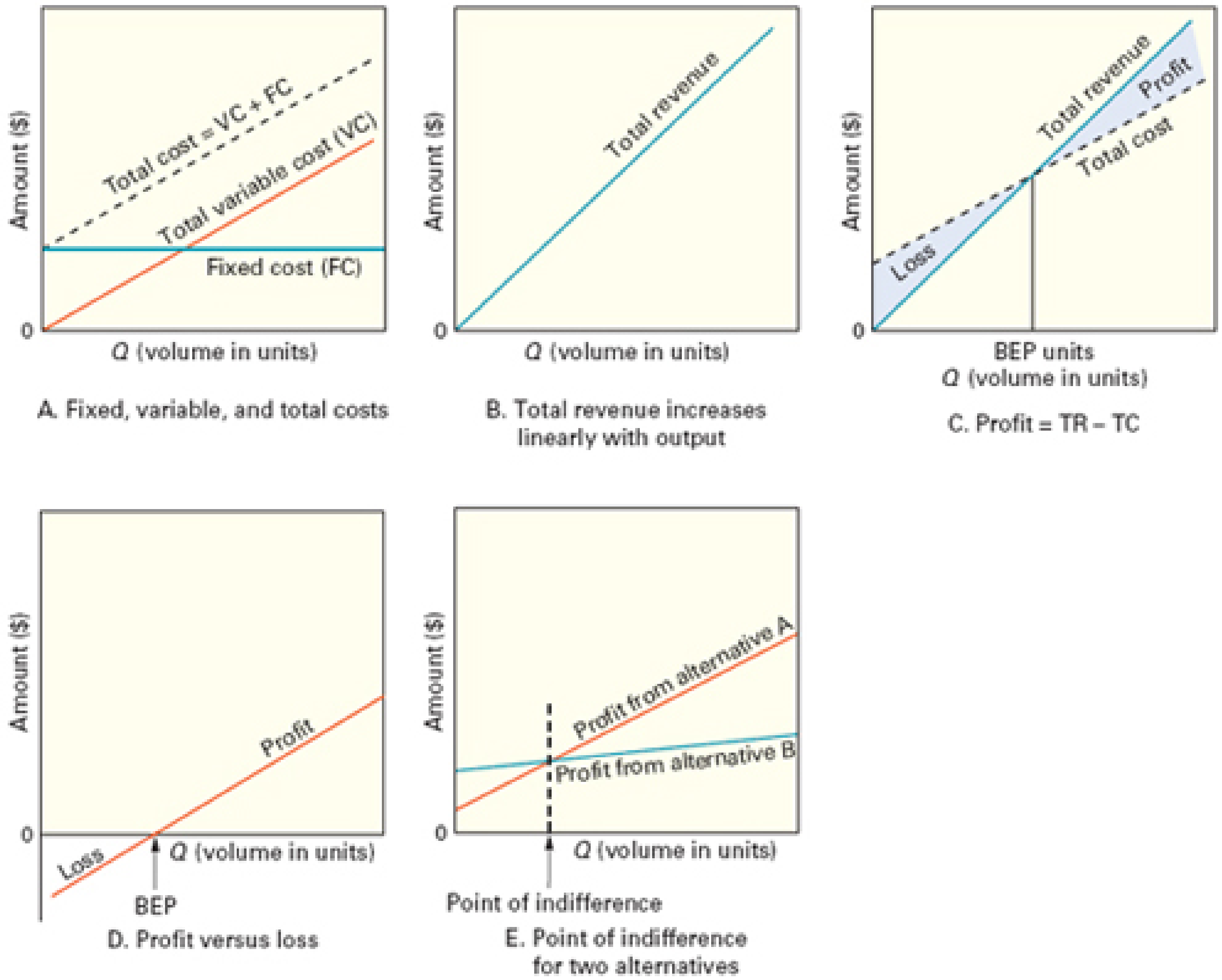
Assumptions of Cost-Volume Analysis

1. One product is involved
2. Everything produced can be sold
3. Variable cost per unit is the same regardless of volume
4. Fixed costs do not change with volume
5. Revenue per unit constant with volume
6. Revenue per unit exceeds variable cost per unit

Cost-Volume symbols

FC = Fixed cost
VC = Total variable cost
v = Variable cost per unit
TC = Total cost
TR = Total revenue
R = Revenue per unit
Q = Quantity or volume of output
Q_{BEP} = Break-even quantity
P = Profit

Cost-Volume Relationships



Cost Volume Relationships

- BEP – Break Even Point
  - Volume of output needed for total revenue equaling total cost
  - Production below BEP quantity results in loss
  - Production above BEP quantity results in profit
  - Production at BEP quantity: no profits, no loss.
- Point of Indifference
  - the quantity at which a decision maker would be indifferent between two competing alternatives

Profit = TR – TC

= TR – (FC+VC)

= TR – VC – FC

= QR – Qv – FC

= Q(R-*v*) – FC

At the break even quantity, Q_{BEP}, Profit = 0

$0 = Q_{BEP}(R-v) - FC$

Example

The owner of Old-Fashioned Berry Pies is contemplating adding a new line of pies, which will require leasing new equipment for a monthly payment of $6,000. Variable costs would be $2 per pie, and pies would retail for $7 each.

a. How many pies must be sold in order to break even?
b. What would the profit (loss) be if 1,000 pies are made and sold in a month?
c. How many pies must be sold to realize a profit of $4,000?
d. If 2,000 can be sold, and a profit target is $5,000, what price should be charged per pie?

Example

FC = $6,000, VC = $2 per pie, R = $7 per pie

a. $$Q_{BEP} = \frac{FC}{R - v} = \frac{6{,}000}{7 - 2} = 1{,}200\ pies/month$$

b. For Q = 1,000, $P = Q(R - v) - \text{FC}$ = 1,000($7 − $2) − $6,000 = −$1,000

c. P = $4,000; solve for Q using Formula 5–7:

$$Q = \frac{\$4{,}000 + \$6{,}000}{\$7 - \$2} = 2{,}000 \text{ pies}$$

d. Profit $= Q(R - v) - \text{FC}$

$5,000 = 2,000($R$ − $2) − $6,000

R = $7.50

Example

A manager has the option of purchasing one, two, or three machines. Fixed costs and potential volumes are as follows:

Number of Machines	Total Annual Fixed Costs	Corresponding Range of Output
1	$ 9,600	0 to 300
2	15,000	301 to 600
3	20,000	601 to 900

Variable cost is $10 per unit, and revenue is $40 per unit.

a. Determine the break-even point for each range.

b. If projected annual demand is between 580 and 660 units, how many machines should the manager purchase?

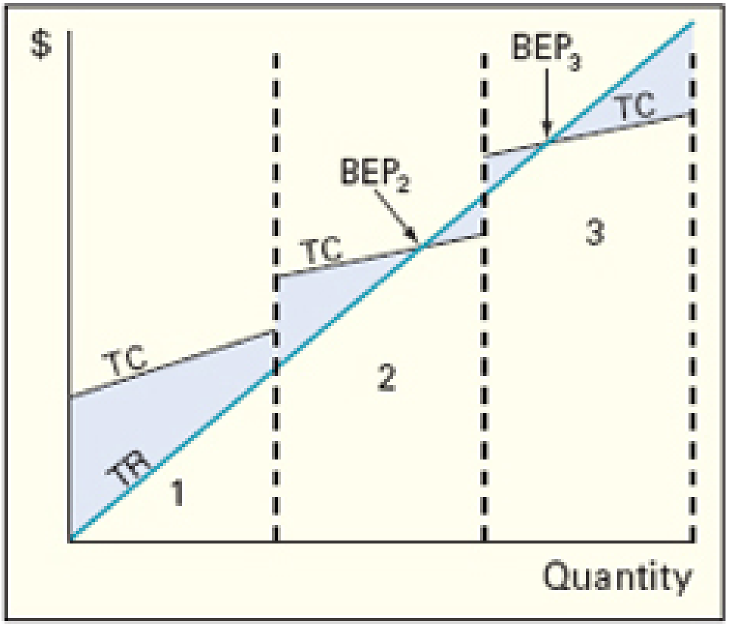
Example

a. Compute the break-even point for each range using the formula $Q_{BEP} = FC/(R - v)$.

For one machine: $Q_{BEP} = \dfrac{\$9,600}{\$40/\text{unit} - \$10/\text{unit}}$ = 320 units [not in range, so there is no BEP]

For two machines: $Q_{BEP} = \dfrac{\$15,000}{\$40/\text{unit} - \$10/\text{unit}}$ = 500 units

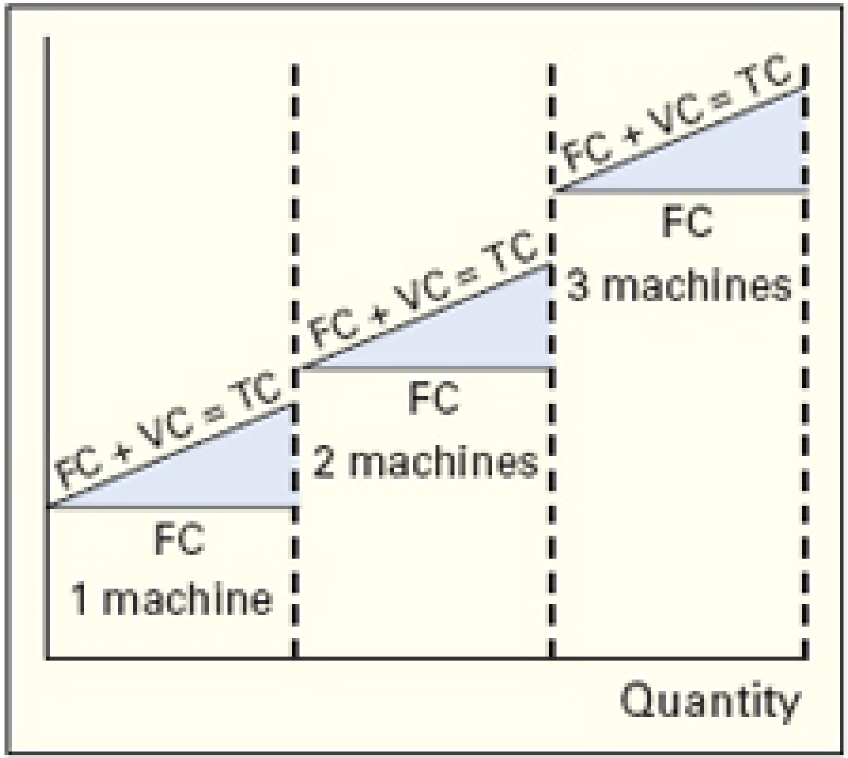
For three machines: $Q_{BEP} = \dfrac{\$20,000}{\$40/\text{unit} - \$10/\text{unit}}$ = 666.67 units



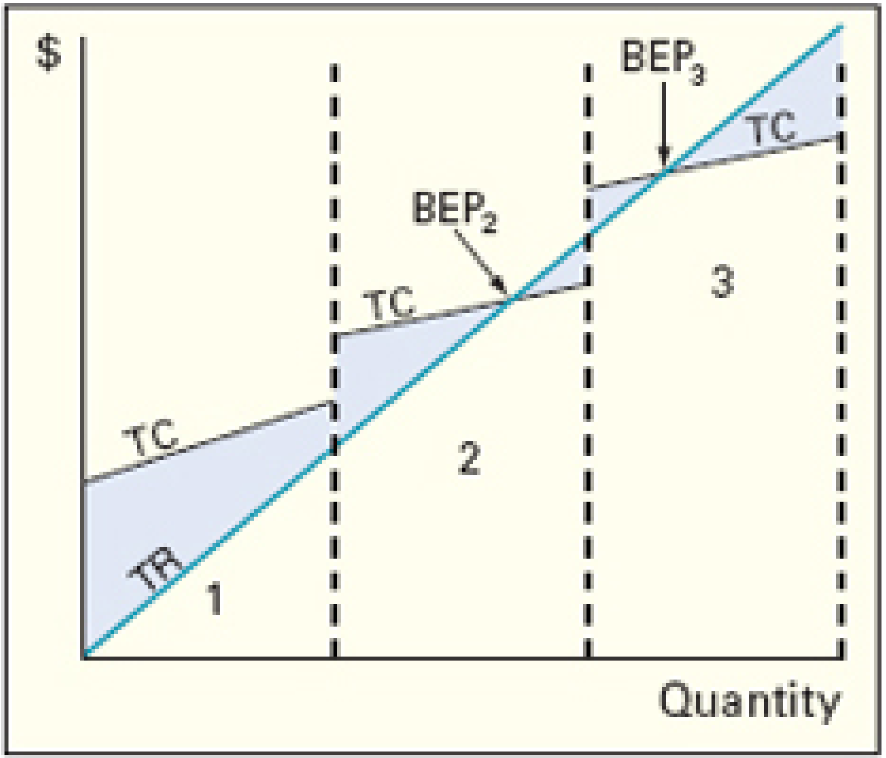
b. Projected demand is between 580 and 660 units. BEP for 2 machines is 500, so 2 machines are suitable for demand up to 600. However, BEP for 3 machine is 667, but the annual demand is no more than 660. So 3 machines is not a feasible option.

We should opt for 2 machines and supply up to 600 units.

Break-Even Problem with Step Fixed Costs



A. Step fixed costs and variable costs



B. Multiple break-even points

Financial Analysis

- Cash Flow - the difference between cash received from sales and other sources, and cash outflow for labor, material, overhead, and taxes.
- Present Value - the sum, in current value, of all future cash flows of an investment proposal.

Decision Theory

- Helpful tool for financial comparison of alternatives under conditions of risk or uncertainty
- Suited to capacity decisions
- See Chapter 5 Supplement

Waiting-Line Analysis

- Useful for designing or modifying service systems
- Waiting-lines occur across a wide variety of service systems
- Waiting-lines are caused by bottlenecks in the process
- Helps managers plan capacity level that will be cost-effective by balancing the cost of having customers wait in line with the cost of additional capacity