Capacity Planning
For Products and Services

Homework Problems: # 1,3,4,12 on pp. 210-211.

Capacity Planning
• Capacity
  • The upper limit or ceiling on the load that an operating unit can handle
• Capacity needs include
  • Equipment
  • Space
  • Employee skills

Strategic Capacity Planning
• Goal
  • To achieve a match between the long-term supply capabilities of an organization and the predicted level of long-run demand
  • Overcapacity → operating costs that are too high
  • Undercapacity → strained resources and possible loss of customers

Strategic Capacity Planning
• Key Questions:
  • What kind of capacity is needed?
  • How much capacity is needed to match demand?
  • When is it needed?
• Related Questions:
  • How much will it cost?
  • What are the potential benefits and risks?
  • Are there sustainability issues?
  • Should capacity be changed all at once, or through several smaller changes
  • Can the supply chain handle the necessary changes?

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
6. Affects ease of management
7. Globalization adds complexity
8. 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*

Q. What are the relationships between the two?

#### Efficiency/Utilization Example

- **Design capacity** = 50 trucks/day
- **Effective capacity** = 40 trucks/day
- **Actual output** = 36 units/day

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

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

### Determinants of Effective Capacity

- Facilities
- Product and service factors
- Process factors
- Human factors
- Operational factors
- Supply chain factors
- External factors

### Strategy Formulation

- Capacity strategy for long-term demand
- Demand patterns
- Growth rate and variability
- Facilities
  - Cost of building and operating
- Technological changes
  - Rate and direction of technology changes
- Behavior of competitors
- Availability of capital and other inputs

### Capacity Strategies

- **Leading**
  - Build capacity in anticipation of future demand increases
- **Following**
  - Build capacity when demand exceeds current capacity
- **Tracking**
  - Similar to the following strategy, but adds capacity in relatively small increments to keep pace with increasing demand

- Strategies are typically based on assumptions and predictions about:
  - Long-term demand patterns
  - Technological change
  - Competitor behavior
Capacity Cushion

- **Capacity Cushion**
  - Extra capacity used to offset demand uncertainty

- **Capacity cushion = 100% - Utilization**

- **Capacity cushion strategy**
  - Organizations that have greater demand uncertainty typically have greater capacity cushion
  - Organizations that have standard products and services generally have smaller capacity cushion

Pressures for Large Cushion

- Uneven demand e.g., seasonal
- Uncertain demand
- Changing product mix
- Capacity comes in large increments
- Uncertain supply

Pressures for Small Cushion

- Capital costs

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

Calculating Capacity Requirements

- Calculating processing requirements requires reasonably accurate demand forecasts, standard processing times, and available work time

\[ N_p = \sum \frac{p_i D_i}{T} \]

where

- \( N_p \) = number of required machines
- \( p_i \) = standard processing time for product \( i \)
- \( D_i \) = demand for product \( i \) during the planning horizon
- \( T \) = processing time available during the planning horizon

Calculating Processing/Capacity Requirements

<table>
<thead>
<tr>
<th>Product</th>
<th>Annual Demand</th>
<th>Standard processing time per unit (hr.)</th>
<th>Processing time needed (hr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>400</td>
<td>5.0</td>
<td>2,000</td>
</tr>
<tr>
<td>#2</td>
<td>300</td>
<td>8.0</td>
<td>2,400</td>
</tr>
<tr>
<td>#3</td>
<td>700</td>
<td>2.0</td>
<td>1,400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5,800</td>
</tr>
</tbody>
</table>

Service Capacity Planning

- Service capacity planning can present a number of challenges related to:
  - **The need to be near customers**
    - Convenience
  - **The inability to store services**
    - Cannot store services for consumption later
  - **The degree of demand volatility**
    - Volume and timing of demand
    - Time required to service individual customers
**Demand Management Strategies**

- Strategies used to offset capacity limitations and that are intended to achieve a closer match between supply and demand
  - Pricing
  - Promotions
  - Discounts
  - Other tactics to shift demand from peak periods into slow periods

**In-house or Outsource?**

- Once capacity requirements are determined, the organization must decide whether to produce a good or service itself or outsource
  - Factors to consider:
    - Available capacity
    - Expertise
    - Quality considerations
    - The nature of demand
    - Cost
    - Risks

**Developing Capacity Alternatives**

- Things that can be done to enhance capacity management
  - Design flexibility
  - Take stage of life cycle into account
  - Take a “big-picture” approach to capacity changes
  - Prepare to deal with capacity “chunks”
  - Attempt to smooth capacity requirements
  - Identify the optimal operating level
  - Choose a strategy if expansion is involved

**Economies of Scale**

- Economies of Scale
  - If output rate is less than the optimal level, increasing the output rate results in decreasing average per unit costs
  - Reasons for economies of scale:
    - Fixed costs are spread over a larger number of units
    - Construction costs increase at a decreasing rate as facility size increases
    - Processing costs decrease due to standardization

**Optimal Operating Level**

- Diseconomies of Scale
  - If the output rate is more than the optimal level, increasing the output rate results in increasing average per unit costs
  - Reasons for diseconomies of scale
    - Distribution costs increase due to traffic congestion and shipping from a centralized facility rather than multiple smaller facilities
    - Complexity increases costs
    - Inflexibility can be an issue
    - Additional levels of bureaucracy
Minimum cost & optimal operating rate are functions of size of production unit.

- Constraint
  - Something that limits the performance of a process or system in achieving its goals
  - Categories
    - Market
    - Resource
    - Material
    - Financial
    - Knowledge or competency
    - Policy

1. Identify the most pressing constraint
2. Change the operation to achieve maximum benefit, given the constraint
3. Make sure other portions of the process are supportive of the constraint
4. Explore and evaluate ways to overcome the constraint
5. Repeat the process until the constraint levels are at acceptable levels

Alternatives should be evaluated from varying perspectives
- Economic
  - Cost-volume analysis
  - Financial analysis
  - Decision theory
  - Waiting-line analysis
  - Simulation
- Non-economic
  - Public opinion

Cost-volume analysis
- Focuses on the relationship between cost, revenue, and volume of output
- Fixed Costs (FC)
  - tend to remain constant regardless of output volume
- Variable Costs (VC)
  - vary directly with volume of output
  - \[ VC = \text{Quantity (Q)} \times \text{variable cost per unit (v)} \]
- Total Cost
  - \[ TC = Q \times v \]
- Total Revenue (TR)
  - \[ TR = \text{revenue per unit (R)} \times Q \]

Break-Even Point (BEP)
- The volume of output at which total cost and total revenue are equal
- \[ \text{Profit (P)} = TR - TC = R \times Q - (FC + v \times Q) \]
- \[ = Q(R - v) - FC \]
- \[ Q_{BEP} = \frac{FC}{R - v} \]
Cost-Volume Relationships

Figure 5.5a

Amount ($) vs. Volume (Q) in units
- Total cost = VC + FC
- Total variable cost (VC)
- Fixed cost (FC)

Figure 5.5b

Total revenue vs. Volume (Q) in units

Figure 5.5c

Amount ($) vs. Volume (Q) in units
- Total revenue
- Profit
- Total cost
- BEP units

Assumptions of Cost-Volume Analysis

- Cost-volume analysis is a viable tool for comparing capacity alternatives if certain assumptions are satisfied
  - One product is involved
  - Everything produced can be sold
  - The variable cost per unit is the same regardless of volume
  - Fixed costs do not change with volume changes, or they are step changes
  - The revenue per unit is the same regardless of volume
  - Revenue per unit exceeds variable cost per unit