Lectures Notes
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IE 505 PRODUCTION PLANNING AND CONTROL

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Course Outline

- Introduction
- Overview of Production and Operations Strategy
- Forecasting
- Aggregate Planning
- Inventory Control (Known and Uncertain Demand)
- Supply Chain Management
- Materials Requirements Planning, Just-In-Time
- Operations Scheduling
- Project Scheduling
- Recent Advances
PRODUCTION AND OPERATIONS STRATEGY
1. INTRODUCTION
1. Introduction

1. Manufacturing/Production Function

\[\text{Resources} \quad \Rightarrow \quad \boxed{\text{Workers} \quad \text{Machines}} \quad \Rightarrow \quad \text{Raw materials} \quad \text{Factory} \quad \text{Finished Goods}\]

2. Functional areas of a firm
   
   2.1. Marketing
   2.2. Finance
   2.3. Production

3. Difference between manufacturing and production?
1. Problems in Production Management

- Inventory
- Production Scheduling and Control
- Equipment Selection and Replacement
- Maintenance
- Size and Location of Plants
- Plant Layout and Structure
- Quality Control and Inspection
- Traffic and Material Handling
- Methods
NEED: US competitiveness; declining exports

What has happened?

- Failure to recognize the size of competitive challenge
- Failure to appreciate the impact of increasing manufacturing capacity in 60’s capacity ≤ demand; now capacity > demand
- Failure to invest in R&D
- Top management’s lack of manufacturing experience
- Production manager’s obsession with short term performance measures

\[
ROI = \frac{Profits}{Investments}
\]
1.B Elements of Production and Operations Strategy

1. Time horizon:
   - Short
   - Medium
   - Long

2. Focus
   - Process Technologies
   - Market Demands (Price, LT, reliability)
   - Production Volume
   - Quality Level
• Manufacturing tasks

3. Evaluation
• Cost
• Quality
• Profitability
• Customer Satisfaction

4. Consistency
• Professionalism
• Product proliferation
• Manufacturing tasks should be made explicit
2. CAPACITY GROWTH PLANNING: LONG-TERM STRATEGIC PLANNING
• Capacity strategy depends on
  1. Demand Pattern
  2. Cost for new facility
  3. New process technology
  4. Competitor’s strategy
• When, Where and How much
2. A Example Problem: Make or Buy decision

Buy from some outside source: \( c_1/\text{unit} \)
Internal production: \( c_2/\text{unit} \)

\( c_2 < c_1 \); Set-up or Investment cost $K to expand

Cost for \( c_1/\text{unit} \) products

BUY \( c_1x \)
MAKE \( K + c_2x \)

\[ x = \frac{K}{(c_1 - c_2)} \]
Cost

Buy
\( c_1x \)

Make
\( k + c_2x \)

Break Even Point

\( x \)
2.B. Dynamic Capacity Expansion Policy

Maximize:

- Market share
- Utilization

Assume: Demand is increasing linearly (deterministic)
\[ D = \text{Annual increase in demand} \]
\[ x = \text{Time interval between addition of successive plants} \]
\[ r = \text{Annual discount rate (compounded continuously)} \]
\[ f(y) = \text{Cost of opening a plant of capacity } y \]
\[ C(x) = \text{Total discounted costs over an } \infty \text{ horizon; given that a plant opens at time } 0 \]
\[ e^{-rx} = \text{NPV of } \$1 \text{ incurred } x \text{ years in future} \]
\[ C(x) = f(xD) + f(xD)e^{-rx} + f(xD)e^{-2rx} + \cdots \]
\[ = f(xD)[1 + e^{-rx} + e^{-2rx} + \cdots] \]
\[ = \frac{f(xD)}{1 - e^{-rx}} \]
2. Capacity Growth Planning: long-term strategic planning
2. Capacity Growth Planning: long-term strategic planning
Empirical evidence from industry

\[ f(y) = ky^a \]

\( a : \) Indicator of Ratio of incremental to average cost of unit plant capacity
\( a < 1; a = 0.6 \) in general

\[ C(x) = \frac{k(xD)^a}{1 - e^{-rx}} \]

To find \( x \) that minimizes \( C(x) \) set \( \frac{dC(x)}{dx} = 0 \)
\[
\frac{dC(x)}{dx} = kD^a \frac{(1 - e^{-rx})ax^{a-1} - xe^{-rx}}{(1 - e^{-rx})^2} = 0
\]
\[
x = \frac{a(1 - e^{-rx})}{re^{-rx}}
\]
\[
a = \frac{rx}{e^{rx} - 1}
\]

Read:

1. Features one needs to consider in capacity planning
2. Issues in plant location
3. LEARNING AND EXPERIENCE CURVES
3. Learning and Experience Curves

Respectively,

Labor hrs/unit vs # units
Marginal production cost vs # units

\[ Y(u) : \# \text{ of labor hours for } u-th \text{ unit} \]
\[ Y(u) = au^{-b} \]

\begin{align*}
  a & : \# \text{ hours for the first unit} \\
  b & : \text{factor for measuring decline in marginal prod. hrs}
\end{align*}

80% learning curve \(\rightarrow\) time for \(2u-th\) unit is 80% of the \(u-th\) unit
\[
\frac{Y(2u)}{Y(u)} = \frac{a(2u)^{-b}}{au^{-b}} = 2^{-b} = 0.80
\]

\[-b \ln 2 = \ln(0.8)\]

\[b = -\frac{\ln(0.8)}{\ln(2)} = 0.3219\]

Usually plot \(\ln Y\) versus \(\ln(\text{cumulative \# units})\)
4. PRODUCT AND PROCESS LIFE CYCLES
Product Life Cycle
1. Start-up
2. Rapid growth
3. Maturation
4. Stabilization/Decline
Process Life Cycle

1. Early - *job-shop*
2. Middle - *automation*
3. Mature - *standardization*

Product-Process Matrix

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<th>low</th>
<th>med</th>
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