CHAPTER - 2

THEORETICAL FRAMEWORK

OF THE STUDY
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2.1.1 OBJECTIVES:

Broadly speaking, inventory management is concerned with the entire range of functions which affect the flow, conservation and utilization, and the quality and cost of materials. Thus, inventory management is everyone's concern. However, it is extremely desirable that there should be one agency within a company which has the responsibility for coordinating the various activities concerned with materials management and be broadly responsible for the function. It is best to locate this responsibility in a materials department headed by a materials manager, preferably having the status. Apart from the task of coordinating with other departments in regard to the control of costs on materials, the activities generally included in the inventory management function are:

1. Materials planning and programming
2. Purchasing
3. Inventory control
4. Receiving and storekeeping
5. Warehousing
6. Transportation
7. Materials handling
8. Disposal of scrap and surplus
9. Value analysis

2.1.2. OBJECTIVES OF INVENTORY MANAGEMENT:

Objectives are the desired end result. The objectives of inventory management are:

1. To ensure continuous and uninterrupted production or operation by maintaining a steady flow of materials.
2. To achieve the above objectives in an efficient and economical manner.
3. To effect economies in the cost of materials by purchasing materials of the right quality in the right quantity at the right time from the right source at the right price.
4. To effect economies in the costs incurred on materials after they have been purchased, through storage, processing and warehousing, till the finished goods ultimately reach the customer. These economies contribute towards cost reduction in production and operation and ultimately to overall costs, thereby leading to higher profits.
5. To reduce working capital requirements.
2.1.2 OBJECTIVES OF THE PROPOSED RESEARCH:

1. To understand the profile of SSI manufacturers in Amravati.

2. To understand awareness about materials management and allied fields such as JIT analysis.

3. To develop training programs and modules for manufacturers regarding inventory policy.

4. To develop a software development for inventory management for SSIs.

5. To study a synchronization between demand and supply of inventory to maintain a smooth production schedule.

6. To create awareness among the manufacturers regarding anticipated changes in lead time and breakdowns of machinery during production.
2.1.3 CLASSES OF INVENTORY:

Plossl and Wigh (1967) classify types of manufacturing inventories according to their condition during processing as follows:

1. Raw materials:

These are the steel, flour, wood, cloth or other materials used to make the components of finished product.

2. Components:

These are parts or subassemblies ready to go into a final assembly of a product.

3. Work-In-Process:

These are materials and components being worked on or waiting between operations in the factory.

4. Finished products:

These are finished items carried in inventory in a make-to-stock plant or finished goods sold to a customer against an order in a make-to-order plant.

The distribution of a firm's inventories depends on the size of market served and the nature of seasonal and cyclical factors.

Figure 2.1 shows typical inventory distributions in four different decision areas inventory levels which are set intuitively are usually either low or too high.

2.1.4 RELEVANT COSTS IN INVENTORY SYSTEM:

There are three major classes of tangible costs associated with the operation of inventory systems. The production and inventory control literature defines these costs as follows:

1. Holding or carrying costs:

This is a broad category of costs which includes the costs for storage facilities, handling, insurance, taxes, pilferage, breakage, obsolescence, depreciation, and the opportunity cost of capital invested on materials.

2. Shortage costs:

These are the costs of lost sales, costs of loss of goodwill and the costs of special administrative efforts such as telephone charges, memoranda, letters and the like.
Figure 2.4 Inventoried Distributions of Four Industries

- Defense
  - Distribution: 48%
  - Raw Material: 8%
  - Finished: 20%
  - Semi-Finished: 40%

- Capital Goods
  - Distribution: 16%
  - Raw Material: 60%
  - Finished: 12%
  - Semi-Finished: 18%

- Consumer Goods
  - Distribution: 20%
  - Raw Material: 80%
  - Finished: 12%
  - Semi-Finished: 28%

- Garment Industry
  - Distribution: 50%
  - Raw Material: 50%
  - Finished: 12%
  - Semi-Finished: 48%
3. Replenishing or ordering costs:
These costs are also referred to as managerial and clerical costs. These are associated with preparing the purchase or production order.

2.1.5 DIFFERENT INVENTORY SYSTEMS:
Inventory systems can be divided broadly into two categories, namely:
Static models; and
Dynamic models.
The static models are derived from the assumption that all model parameters, such as rate of demand and lead time, are constant. The classical lot size model, or the economic order quantity (EOQ) model, as published by Harris (1915) is an example of the static type model.
On the other hand, dynamic models are based on the assumption that one or more of variables, e.g., rate of demand and lead time, that affect the total inventory costs may vary over a number of possible values. The model developed by Wagner and Whitin (1958) representing the cost consequences of stock level decisions for a single product, over several periods under conditions of varying known demands, is a classical dynamic type model.

2.1.6 PARAMETERS AND FACTORS IDENTIFIED IN INVENTORY MODELS:
The earliest known analysis of an inventory system was by F.W. Harris (1915). Harris first published the classical lot size i.e. economic order quantity (EOQ) formula as:

$$q_o = \sqrt{\frac{2DS}{h}}$$

where $q_o$ = optimal lot size
D = rate of demand per unit time
S = cost of replenishing the inventory
h = carrying cost one unit inventory per unit time
The EOQ formula represents a balance between conflicting objectives of economics of scale in replenishing and costs associated with carrying inventory. This formula is also referred to as the "Wilson formula" (Buffa and Taubert, 1972).
The inventory parameters and factors that researchers have included in the development of inventory models are identified and summarized as below:
1. Types of demands: constant, known distribution or unknown distribution.

2. Cost functions (for ordering, carrying and shortage inventory items): constant, linear, convex or concave.

3. Lead times: zero, constant, known or unknown distribution, or dependent on some other system parameter such as the number of outstanding orders.

4. Amounts of order quantity actually received: 100% received, less than 100% received with known or unknown distribution;

5. Interdependence between demand of items: single item case, or multi-item case;

6. Interdependence between locations and or echelons: single location or single echelon, multi location, multi echelon or multi location and multi echelon;

7. Discounting of future costs: constant, or variable discount factor;

8. Various types of constraints: storage space, capital, production capacity, vendor's supplies, order size, recession in the market, less capacity optimization, etc.;

9. Types of backlogging policies: no backlogging, partial or complete backlogging;

10. Conditions of obsolescence or perishability of products: no deterioration with time, or deterioration with time accompanied by proportional loss in value of the products;

11. Types of planning horizons: finite or infinite planning horizon;

12. Types of planning periods: single or multi-period planning;

13. Review method: continuous or periodic review.

An overwhelming number and variety of inventory models have been developed by combining these characteristics. An impressive number of combinations is possible that there are such an enormous number of special cases in the general area of inventory problems that it would require an encyclopedia to discuss all of them. (Starr and Miller, 1962).

2.1.7 DEPENDENT - INDEPENDENT DEMAND RELATIONSHIPS:

Materials requirements planning (MRP) which appeared as a concept for the management of inventory systems around 1960, is based upon fundamental principle of the concept of dependent versus independent demand.

Demand for a given item is considered to be independent when it is unrelated to the demand for other items. Demand for each finished product, called an end item, and demand for each replacement part is independent of demand for
other end items and replacement parts. Conversely, demand for an item is defined to be dependent when it is directly related to the demand for one or more inventory items, as is the case when the item is a component part of some other item. The dependent-independent demand relationship can best be highlighted through the examination of a bill of materials (BOM). A BOM is constructed by taking a product or assembly and breaking it down or exploding it into its individual components. A trace through a product's BOM will yield an exact amount of all other items and materials required to manufacture that product. Demands for end items and replacement parts are specified by the master production schedule (MPS). A MPS specifies independent demands in terms of production requirements by period across a planning horizon. The BOM can then be used to convert MPS specifications of independent demands into dependent demands for each component part and assembly across the same planning horizon. The major elements of MRP and their interrelationships, as described by Miller and Strugupe (1975) are illustrated in Figure 2.

Factory magazine in cooperation with the American Production & Inventory Control Society (APICS) conducted a survey in 1973 to determine the extent of use of various formal inventory techniques and procedures by practitioners. The results of the survey summarizing 18846 usable responses out of nearly 8000 APICS members, showed the six most frequently used techniques in terms of % of use as below:

ABC Principle 62%
Economic Order Quantity (EOQ) 56%
Materials Requirements Planning (MRP) 47%
Statistical Reorder Point calculation 32%
Exponential Smoothing 30%
Capacity Planning 30%
Figure 2.2
MRP TIME PHASED PLANNING

LEVEL

0

1

2

3

ASSEMBLIES

COMPONENT PARTS

END PRODUCTS

INDEPENDENT DEMAND

DEPENDENT DEMAND

CUMULATIVE PRODUCT LEAD TIME
2.2.1 PRODUCTIVITY : ITS NATURE AND SIGNIFICANCE:

In an industrial economy, the costs can be reduced by either reducing the absolute costs or by improving the products. Absolute costs in the present set-up cannot be reduced. Therefore, every enterprise has to maximize productivity. High productivity means doing a piece of work in the shortest possible period of time incurring the least expenditure on inputs, without comprising on quality or workmanship, with a minimal wastage of resources that are used in the most cost-effective manner.

\[
\text{Productivity Index} = \frac{\text{Performance achieved}}{\text{Resources consumed}}
\]

\[
\text{Effectiveness} = \frac{\text{Efficiency}}{\text{Resources consumed}}
\]

Productivity denotes the efficiency with which output is produced by the resources utilized. It is usually measured as a ratio relating output (goods, commodities, products, services, etc.) to one or more of the inputs (labor, capital, materials, fuel and energy, etc.) associated with the output. It expresses the volume of goods and services produced in terms of the quantities of inputs required to produce them. Production inputs involve costs. Productivity relates output to all inputs to assess net savings in real costs per unit of output. Productivity gains emerge from improvements in techniques, technology and management, of production process. These improvements result in higher production and/or lower costs.

Productivity signifies a continual striving toward economically most efficient mode of production of goods, commodities, systems and services, needed by a society. It has been a most important requirement for raising the living standard of people in a nation. Higher per capita incomes of developed countries reflect their higher levels of productivity. It has been estimated that up to one third, or more, of the annual growth in the gross domestic product (GDP) of industrial nations stems from their productivity gains as distinct from growth through additional investments. Low and stagnant per capital incomes in underdeveloped countries, analogously reflect their low levels of productive capabilities. Productive efficiency is of crucial importance for managing inflation by lowering the costs of goods, services, and commodities consumed by people. Productivity is the essential requisite for increasing exports, achieving export-led growth, attaining techno-economic development, and generating wealth for investment, consumption and social welfare.
2.2.2 FACTORS AFFECTING PRODUCTIVITY:

- Investment
- Capital/labor ratio
- R & D
- Capacity utilization
- Govt. regulations
- Age of plant & equipment
- Energy costs
- Available technology
- Work-force mix
- Management of the enterprise
- Inventory control

2.2.3 ORGANIZATIONAL DETERMINANTS OF PRODUCTIVITY INNOVATION

Pursuit of productivity and innovation in organizations is bound up with a common set of determining factors. The major ones among them may be listed as follows:

1. Optimal location, capacity and layout of the plant
2. Full utilization of production capacity by developing the competitiveness of products in terms of quality and price.
3. Rationalization of work flow.
4. Effective personnel policies for the recruitment, training, assignment and promotion of persons on the basis of ability, merit and performance. & the innovative ability to find solutions on the spot
5. Optimal scheduling of work and materials handling.
6. Optimal planning of inventory levels, production facilities and plant maintenance.
7. Effective control over costs, and quality.
9. Formulation, initiation, and implementation of productivity improvement measures with the involvement of employees.

10. Regular monitoring of market, and technical environment for timely information about new developments in production technology, possibilities of innovation and market changes.

11. Upgradation of work skills of organization personnel, through periodic programs of creative training.

12. Modernization of plant and machinery through internal R & D work, and/or adoption of new technology from other sources.

13. Development of new improved products through internal R & D and/or import, and assimilation of new technology.

14. Scope and flexibility for internal entrepreneurs of "product champions" to experiment with and develop new product concepts, and tolerance for failure of such efforts.

15. Building an organizational culture of productivity, based on the ethos of competence, commitment & cooperating at all levels.

2.2.4 CAUSES OF PRODUCTIVITY DECLINE IN INDUSTRIES:

Mali (1978) discussed in length 12 causes for the decline of productivity in industries:

1. Inability to measure, evaluate, and manage the productivity of white-collar employees. This causes a shocking waste of resources.

2. Rewards and benefits given without requiring the equivalent in productivity and accountability. This causes spiraling inflation.

3. Diffused authority and inefficiency in complex organizations, thereby causing delays and time-lags.

4. Organizational expansion that lowers productivity growth. This results in soaring costs.

5. Low motivation among a rising number of affluent workers with new attitudes.

6. Late deliveries caused by schedules that have been disrupted by scarce materials.

7. Unresolved human conflicts and difficulties in team work, resulting in the firm's ineffectiveness.

8. Increased legislative intrusions or antiquated laws, resulting in constrained management options and prerogatives.
9. Specialization in work processes resulting in monotony and boredom.

10. Rapid technological changes and high costs, resulting in a decline in new opportunities and innovations.

11. Increasing demand of leisure time causing disruption of time commitments.

12. Practitioner's inability to keep pace with latest information and knowledge.

**2.2.5 PRODUCTIVITY MODELS:**

Productivity denotes the relationship between use of resources and the results of that use. Productivity measures the efficiency and effectiveness with which a production process converts inputs into outputs. This measurement is usually expressed in the form of a family of ratios of output to inputs, in terms of quantity and/or monetary value. A number of productivity measures have been developed depending upon the objectives of assessment and comparison. They may relate either one type of input (labor, capital, materials, energy, etc) or all inputs to output. Both partial, and total productivity ratios are highly useful for purposes of planning, monitoring, control and evaluation (Sumanth, 1990)

**Partial Productivity Ratios:**

A common measure of productivity relates to per labor unit (worker-hour, man-days, unit-labor cost, etc). Some of the Indices of Labor Productivity are expressed as follows:

1. \[
\frac{\text{Physical Output}}{\text{Man-Hours}}
\]

2. \[
\frac{\text{Value of Output - Material's Cost}}{\text{Labor Cost}}
\]

3. \[
\frac{\text{Value Created}}{\text{Labor Input}}
\]

Partial Productivity Indices focus on measuring the role of a single and particular input factor for the purpose of evaluating comparison. They are usually expressible in the following form:
Output

One Factor of Input

Material Usage Efficiency, for example, would be measurable by the ratio:

\[ \frac{\text{Output}}{\text{Materials Volume}} \]

Productivity of Capital Assets is measurable by the following ratio:

\[ \frac{\text{Value of Total Output} - \text{Input of Materials in Value}}{\text{Labor Costs} + \text{Input of capital Equipment in Value}} \]

**TOTAL PRODUCTIVITY RATIOS**

Assessment of productivity in terms of value added per unit of output, is another useful measure. It is represented in terms of the following expression:

\[ \frac{\text{Value of Output} - \text{Cost of Inputs}}{\text{Physical Output}} \]

**MODELS OF PRODUCTIVITY MEASUREMENT**

A model of productivity measurement developed by the American Productivity Center takes the concept of profitability as its point of departure. A brief description of this model may be outlined as follows:

\[ \text{Profitability} = \frac{\text{Sales}}{\text{Costs}} = \frac{\text{Output Quantity} \times \text{Prices}}{\text{Input Quantity} \times \text{Prices}} = \left( \frac{\text{Output Quantity}}{\text{Input Quantity}} \right) \times \left( \frac{\text{Prices}}{\text{Unit Costs}} \right) = (\text{Productivity}) \times (\text{Price Recovery Factor}) \]
The productivity ratio gives an indication of the amount of resources consumed to produce the output of the enterprise. Appropriate inventory change figures can be brought in here, to adjust the differences between sales and production data. The changes in price recovery factor over time indicate whether changes in input costs are absorbed, passed on, or over compensated for, in the prices of the firm's output.

2.2.6 PRODUCTIVITY INDICATORS BY FUNCTIONAL DEPARTMENTS (INDUSTRIAL COMPANIES):

In a survey conducted by Lee and Packer (1981), the companies were asked to list the top most useful productivity indicators that they use in 17 functional departments: manufacturing, sales, marketing, purchasing, personnel, finance, accounting, legal, engineering, research and development, quality assurance, maintenance, industrial engineering, data processing, administration, word processing, distribution/warehousing and planning. The productivity indicators reported by the 61 industrial companies were compiled in 4 categories under each of the 17 functions (tables no. 2.1-2.5).

(Sumanth, 1990) These categories are:

Partial productivity indicators, total factor productivity indicators, total productivity indicators and other non-standard productivity indicators. The last category includes all those indicators that cannot be categorized in the first three.

Table 2.1: Most commonly used productivity indicators in the manufacturing function (industrial companies):

<table>
<thead>
<tr>
<th>Commonly used productivity indicators</th>
<th>Number of times mentioned</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Partial productivity measures:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Human productivity indicators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- output/man-hour</td>
<td>30</td>
<td>41.1</td>
</tr>
<tr>
<td>- units/man-hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- value added/labor-hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- production/hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- output/man number/man-hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Real output/employee:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- sales value of production/person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- unit output/employee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- net income/100 payroll</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- production value/labor Dollar</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
c. Machine productivity indicators:
   - output / machine hr,
   - tons / machine hr.

d. Energy productivity indicators:
   - production value / energy consumed
   - barrel production / barrel fuel

e. Space productivity indicators:
   - units / $ factory space.

f. Fixed capital productivity indicator:
   - barrel production / plant replacement value

2. Total factor productivity measures
   - value added (labor + capital) input

3. Total productivity measures
   - total productivity index
   - output / input (constant $)

4. Other non-standard productivity measures
   - man- hrs / unit
   - man- power / unit
   - cost / unit
   - factory cost / unit
   - assembly hrs / structure pound
   - manufacturing expense / direct labor

c. Labor efficiency:
   - standard hrs produced
   - standard hrs reduced
   - standard hrs
   - manpower efficiency
   - labor standard hrs / $1000 sales
   - actual labor hrs / standard hrs
   - actual units / standard units

d. Volume produced:
   - cost, schedules, yields, weight

Table 2.2: Most commonly used productivity indicators in the purchasing function (industrial companies):

<table>
<thead>
<tr>
<th>Commonly used productivity indicators</th>
<th>Number of times mentioned</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Partial productivity measures:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Human productivity indicators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- purchases / person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- purchase orders processed / person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- purchases / buyer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

36
2. Total factor productivity measures

3. Total productivity measures

4. Other non-standard productivity measures:
   - manpower / unit
   - total purchased $ flow through
   - invoices / employee
   - inventory turnover
   - inventory value / expense
   - cost / sale value
   - material cost increase / inflation rate
   - actual production vs budget
   - standard hrs / actual hrs
   - discounts, backorders
   - price vs market % of $ purchased saved

Table 2.3: Most commonly used productivity indicators in the engineering function (industrial companies):

<table>
<thead>
<tr>
<th>Commonly used productivity indicators</th>
<th>Number of times mentioned</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Partial productivity measures:</td>
<td>2</td>
<td>8.3</td>
</tr>
<tr>
<td>- sales value / person</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- number drawings / draftsman hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Total factor productivity measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Total productivity measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Other non-standard productivity indicators</td>
<td>22</td>
<td>91.7</td>
</tr>
<tr>
<td>- manpower / unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- quality of facility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- weighted projects completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- % completed on time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- cost / drawing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- changes / drawing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- engineering cost / total project cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- design hrs / elapsed hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- man years / capital expense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- engineering expense / sales</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- return on investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- estimated cost / actual cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- standard hrs / actual hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- actual / planned performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- changeable man-hrs / draftsman hrs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

24 100.0
<table>
<thead>
<tr>
<th>Function</th>
<th>Partial productivity indicators</th>
<th>Total-productivity</th>
<th>Total productivity</th>
<th>Other non-standard productivity indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number times reported</td>
<td>%</td>
<td>Number times reported</td>
<td>%</td>
</tr>
<tr>
<td>1. Manufacturing</td>
<td>30</td>
<td>41.1</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>2. Sales</td>
<td>16</td>
<td>39.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>3. Marketing</td>
<td>6</td>
<td>22.2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>4. Purchasing</td>
<td>4</td>
<td>15.4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>5. Personnel</td>
<td>3</td>
<td>11.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>6. Finance / Accounting</td>
<td>5</td>
<td>23.8</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>7. Legal</td>
<td>1</td>
<td>14.3</td>
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<tr>
<td>8. Engg</td>
<td>2</td>
<td>8.3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>9. R &amp; D</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>10. Quality assurance</td>
<td>7</td>
<td>21.2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>11. Maintenance</td>
<td>5</td>
<td>14.3</td>
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<td>0.0</td>
</tr>
<tr>
<td>12. Industrial engineering</td>
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<td>0.0</td>
</tr>
<tr>
<td>13. Data processing</td>
<td>2</td>
<td>7.7</td>
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<td>0.0</td>
</tr>
<tr>
<td>14. Administration</td>
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<td>18.2</td>
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<td>0.0</td>
</tr>
<tr>
<td>15. Word processing</td>
<td>10</td>
<td>55.6</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>16. Distribution warehousing</td>
<td>7</td>
<td>24.1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>17. Planning</td>
<td>1</td>
<td>12.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Average (%)</strong></td>
<td><strong>19.4</strong></td>
<td><strong>0.1</strong></td>
<td><strong>0.2</strong></td>
<td></td>
</tr>
</tbody>
</table>
Productivity indicators of by functional departments (non-industrial companies):

The productivity indicators reported by the 29 non-industrial companies were compiled in 4 categories under each of the 17 functions. The table 2.5 shows the results.

Table 2.5: Productivity indicators in non-industrial companies: A summary

<table>
<thead>
<tr>
<th>Function</th>
<th>Partial productivity indicators</th>
<th>Total-productivity</th>
<th>Total productivity</th>
<th>Other non-standard productivity indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number times reported</td>
<td>%</td>
<td>Number times reported</td>
<td>%</td>
</tr>
<tr>
<td>1. Manufacturing</td>
<td>09</td>
<td>36.0</td>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>2. Sales</td>
<td>12</td>
<td>42.9</td>
<td>1</td>
<td>3.6</td>
</tr>
<tr>
<td>3. Marketing</td>
<td>1</td>
<td>9.1</td>
<td>1</td>
<td>9.1</td>
</tr>
<tr>
<td>4. Purchasing</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>5. Personnel</td>
<td>1</td>
<td>8.3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>6. Finance/Accounting</td>
<td>5</td>
<td>31.3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>7. Legal</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>8. Engg</td>
<td>3</td>
<td>30.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>9. R &amp; D</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>10. Quality assurance</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>11. Maintenance</td>
<td>2</td>
<td>18.2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>12. Industrial engineering</td>
<td>1</td>
<td>10.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>13. Data processing</td>
<td>1</td>
<td>6.7</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>14. Administration</td>
<td>2</td>
<td>20.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>15. Word processing</td>
<td>8</td>
<td>53.3</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
2.2.7 TECHNIQUES FOR IMPROVING THE ORGANIZATION OF PRODUCTION PROCESS:

Reduced cost of production depends in an important manner, on the organization of production process. Efficiency and effectiveness of production scheduling, materials handling, maintenance of plant and machinery, inventory control, knowledge-based decision making procedures, etc., are vital for the smooth and economical operation of production systems. Poor organization of production process is evidenced by frequent disruptions, delayed schedules, wastage of time, energy, and materials, poor quality of products, and escalation of costs. Proper implementation of productivity techniques is also not possible under disorganized conditions.

Methods and techniques for improving the organization of production process are many. Prominent ones among them may be enumerated as follows:

1. Production Scheduling
2. Just-In-Time (JIT) i.e. Kanban system of Inventory & Scheduling
3. Materials Management
4. Zero Base Budgeting
5. Network Analysis
6. Management Information System (MIS)
7. Decision Support System (DSS)
8. System Simulation and Policy Experiments
Figure: PRODUCTIVITY IMPROVEMENT CYCLE
2.2.8 THE (BASIC) TOTAL PRODUCTIVITY MODEL (TPM):

The total productivity model is a basic model from which several versions are derived. It is based on a "total productivity" measure and a set of five partial productivity measures. The model can be applied in any manufacturing company or any service organization. Total productivity, as we define it in the TPM, is given by the following:

\[
\text{Total productivity} = \frac{\text{Total tangible output}}{\text{Total tangible input}}
\]

where

\[
\begin{align*}
\text{Total tangible output} &= \text{value of finished units produced} \\
&\quad + \text{value of partial units produced} \\
&\quad + \text{dividends from securities} \\
&\quad + \text{interest from bonds} \\
&\quad + \text{other incomes}
\end{align*}
\]

and

\[
\begin{align*}
\text{Total tangible input} &= \text{value of (human + material + capital)} \\
&\quad + \text{energy + other expenses) inputs used}
\end{align*}
\]

The tangible output and tangible input elements of this total productivity definition are shown in Figure 2. By tangible we mean inherently (or directly) measurable. The number of automobiles assembled, the number of checks processed, the tons of steel produced are examples of tangible output. But the amount of pollution created by an organization is an indirectly (intangible) output for which some expenditures have been incurred in anti-pollution devices. The amount of goodwill generated by an organization is another example of an output element that is not tangible. The intangible output and input elements are relatively small in comparison with the total tangible output and input, and they may be ignored for practical purposes.

It should be noted that the output here refers to all the output produced and the input refers to all the resources consumed or expended to produce this output. Both the output and input are expressed in constant monetary terms of a base (reference) period. In other words, the tangible output and input elements are not in the same units. E.g., human and energy input may be expressed in man-hours and kilowatt-hours. Further, if an industry manufactures more than one product—say, e.g., steel (in tons) and shoes (in pair numbers)—the finished unit output cannot be expressed as tons of steel + pairs of shoes. Instead, their value can be expressed in base-period Rs., which can be added together.
Figure 2.1.1: PRODUCTIVITY BENEFIT MODEL
Most total productivity measures proposed in the literature aim at providing a total productivity index for an industry as a whole. The recognition of the importance of measuring the total productivity in organizations in recent years, though at the firm level, has been an encouraging start. However, the usefulness of an exclusively firm-level measure is limited, because it does not tell the management of the firm which of its products or services is causing a decline or growth in the firm's total productivity index. Nor does it tell them which particular inputs—human, material, capital, energy or other expense—are being utilized inefficiently so that corrective action can be taken. An aggregate total productivity measure does not help a firm's management discern the profitability of its products or services. What we need, then, is a productivity index to indicate the productivity health of profitability of its products or services. The TPM is such a productivity measurement system.

2.2.9 SALIENT FEATURES OF TPM:

Some of the salient features of the TPM are as follows:

1. It provides both aggregate (firm level) and detailed (operational unit level) productivity indices.
2. It points out which operational units are profit making and which are not.
3. It shows which particular input resources are being utilized inefficiently so that corrective action can be taken.
4. It tends itself to mathematical treatment so that sensitivity analysis and model validation become relatively easier.
5. It is integrated with the evaluation, planning, and improvement phases of the productivity cycle. i.e., the TPM offers for the first time, a way of not only measuring but also evaluating, planning, & improving the overall productivity of an organization as a whole as well as its operational units.
6. It offers the advantages of management by exception by providing a means to more tightly control the total productivity of major operational units, while providing a routine control for the less critical operational units.
7. It provides valuable information to strategic planners in making decisions related to diversification and phase outs of products or services.

2.2.10 BASIC PRODUCTIVITY IMPROVEMENT TECHNIQUES:

In a comprehensive survey of the literature, more than 50 different techniques of productivity improvement were cataloged (Sumanth & Omachona, 1982). These are classified into 5 basic types:

1. Technology-based
2. Employee-based
3. Product-based

4. Process-based

5. Material-based

These techniques are listed below:

1. Technology-based techniques:

* Computer-Aided Design (CAD)
* Computer-Aided Manufacturing (CAM)
* Integrated CAM
* Robotics
* Laser beam technology
* Energy technology
* Group technology
* Computer graphics
* Emulation
* Maintenance management
* Energy conservation

2. Employee-based techniques:

* Financial incentives (individual)
* Financial incentives (group)
* Fringe benefits
* Employee promotions
* Job enrichment
* Job enlargement
* Job rotation
* Worker participation
* Skill enhancement
* Management By Objectives (MBO)
* Learning curve
* Communication
* Working condition improvement
* Training
* Education
* Role perception
* Supervision quality
* Recognition
* Punishment
* Quality circles
* Zero defects

3. Product-based techniques:

* Value engineering
* Product diversification
* Product simplification
* Research and development
* Product standardization
* Product reliability improvement
* Advertising and promotion

4. Task-based techniques

* Methods engineering
* Work measurement
* Job design
* Job evaluation
* Job safety design
* Human factors engineering (Ergonomics)
* Production scheduling
* Computer-aided data processing

5. Material-based techniques:

* Inventory control
* Materials Requirements Planning (MRP)
* Materials management
* Quality control
* Materials handling systems improvement
  * Material reuse and recycling.

2.2.11 METHODOLOGY OF ENHANCING PRODUCTIVITY IN SMALL ENTERPRISES

BY INVENTORY-BASED TECHNIQUES:

Inventory is a cushion between production & consumption of goods. These inventories may exist in various forms: as stocks of partially completed products, components, as maintenance repairs & operation items, as finished goods in the retail store, to anticipate or entice consumer demand. At each of these stages, there are in general, fully justifiable & economic reasons for the existence of inventories. On the other hand, there are distinct costs generated by the existence of each of these types of inventories. From the point of view of the enterprise, each additional item carried on inventory implies certain very real additional costs. Effective inventory management is essentially a process of selecting the best balance of many & opposing cost factors.

Historically, the management of inventories has been an intuitive process based on judgment & experience. In times of less extensive & more stable product lines, the traditional approach of inventory control proved an effective method. Today, the diversity of product lines has placed impossible demands on the intuitive approach. In addition, dynamic nature of the product lines reduces the effectiveness of experience, in controlling ever-changing inventory structures. Effective inventory management is therefore an integrated system of reporting, analysis, interpretation & decision. A rational approach combines the techniques for controlling inventory with system analysis. Such a combined approach leads to better information flows, more effective decision-making, better returns from funds invested & improved flexibility to adopt to rapidly changing situations.
2.2.12 SCOPE FOR SELECTING INVENTORY - BASED PRODUCTIVITY IMPROVEMENT TECHNIQUES:

Inventory & materials management is one of the key factors for improving performance of any industrial enterprise.

Higher inventories saddle an organization with avoidable costs besides blocking scarce funds which might be required by the enterprise for its own operations. In other words, excessive (more than ideal) inventories would mean tie-up of large amounts of working capital which in turn means money to be borrowed at interest incurring high opportunity costs & facing a large potential for devaluation, deterioration, damage, obsolescence, etc.

Insufficient (lower than ideal) inventories would mean added costs of operation in the form of reduced manufacturing & operating efficiency, increased overhead costs, e.g., work stoppages, extra machine set-up, short runs & also other intangibles like lost sales, loss of customer goodwill, etc.

The impact of excessive/insufficient inventories on cost of a product are summarized in Table - 2.7

<table>
<thead>
<tr>
<th>Area</th>
<th>Excessive Inventories</th>
<th>Insufficient Inventories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Material cost</td>
<td>Greater loss due to a) Devaluation b) Shelf deterioration/damage c) obsolescence</td>
<td>Higher prices &amp; mfg. costs due to small quantities orders &amp; also rush orders</td>
</tr>
<tr>
<td>2. Factory cost</td>
<td>Increase in factory cost due to lack of storage space resulting in inefficient working conditions</td>
<td>Increase in factory cost due to a) work stoppages b) extra machine setup c) expenses on staff training d) reduced operation</td>
</tr>
<tr>
<td>3. Overhead costs</td>
<td>Increases due to a) Interest on cash borrowed b) additional insurance costs</td>
<td>Increases due to additional cost incurred in frequent purchasing, handling, receiving, inspection</td>
</tr>
<tr>
<td>4. Intangibles</td>
<td>Reduced availability of cash for investment opportunity cost</td>
<td>a) lost sales b) loss of goodwill</td>
</tr>
</tbody>
</table>
Distribution of cost in a manufacturing organization is shown in Figure 2.2.

Proper management of inventories & materials, therefore, assumes considerable importance in corporate functioning.

Thus, there must exist some optimum inventory policy which balances the demands of the production & transportation facilities & the implications of consumer demand against the financial restrictions of excessive inventories.
2.2.13 PRINCIPLES OF PRODUCTIVITY IMPROVEMENT:

The following principles must not be considered as a cure—all for all the productivity problems in an organization, but rather as some guidelines for sound management of productivity. Also, these principles must not be viewed as an exhaustive list of all possible strategies. Finally, these principles are not listed in any relative order of importance. (Sumanth 1990)

2.2.13.1 Microprocessor Principle:

Whenever and wherever possible, design products and processes with microprocessor control.

The use of the microprocessor creates built-up in productivity and quality levels that may not be ordinarily achieved unless formal efforts are made once the product and process are designed.

In 1910, America's Bell System handled 6 million telephone calls per year and employed 1,20,000 people, which resulted in a labor productivity of 50 calls/employee. Because of the rapid use of microprocessor-based techniques, in 1979 the Bell System handled 185 billion calls and employed 1 million people, resulting in a labor productivity of 1,85,000 calls/employee. If the same technology as in 1910 were to have been used, Bell would have needed 40 times the entire labor force in the United States.

A typical microprocessor unit (MPU) which is a complex, integrated circuit, can have several thousands of resistors, diodes, transistors, etc. On a single piece of silicon less than 1/16 of an inch square and can therefore, replace several printed circuit boards (PCBs), which are traditionally used in many electronic products and processes.

By drastically reducing the mechanical, electrical and electronic components through the use of microprocessors, reliability can be built into a product or process. The reduction in the type and size of components will also save large amounts of money in inventories and replacement parts.

2.2.13.2 Global-market principle:

Design and manufacture products for global markets. By going for global markets, a company will strive to produce the most competitive products in the domestic and international markets.

Even though the Japanese might not have been presented this principle in the way it has been here, they surely seem to have recognized its importance. Today, if Japanese cameras, tape recorders, video recorders steel, and automobiles are competing so well with the well-established competitors in the world markets, it is because of the
Japanese strategy of building products that compete anywhere in the world, not just in Japan.

2.2.13.3 Learning curve principle:

Wherever possible, plan productivity levels and product costs on a learning curve.

One of the most ignored phenomena in operations of a company is the existence of a learning curve. What is a learning curve? Whenever the time needed to do a task reduces by a constant proportion for every doubling of output quantity, we have a learning curve. Consider the example:

We have assumed 80% learning curve, just to illustrate the principle. When 50 units were produced, the time to produce each unit was 2,500 minutes. When the production eventually reached twice the previous level i.e., 100 units, the time to produce each unit dropped to 80% of the previous level, namely 0.80 \times 2.5 = 2.00 minutes. Next, when the production level was doubled to 200 units, the time/unit ratio dropped to 0.80 \times 2.00 = 1.60 minutes, and so on. In other words, the total time for the next 100 units was much smaller than that for the previous 100 units and so on.

2.2.13.4 Secrecy principle:

Productivity improvement strategies that are novel when compared to the competitors must be kept secret.

Very often, for the sake of publicity, organizations and individuals working for them, tend to leak some strategies that are of strategic importance to them in improving the productivity levels and growth rates. Of course, national ideologies and culture have something to do with such tendencies, but there are many avoidable situations where organizations give away their secrets to suppliers, vendors, and visitors, even to competitors. Management policies must restrict such practices if the gains in productivity are to be substantial enough to counter competitor’s strategies.

2.2.13.5 Product-mix principle:

Develop a product mix that consistently shows the largest gains in total productivity and market share.

The productivity of the firm is the weighted sum of the total productivities of individual operational units. In a manufacturing company, the most commonly identified operational unit is the product. Therefore, if such a company were to concentrate its marketing and production efforts on those products that account for the largest part of its business and that are produced with the greatest efficiency possible, it has a better chance of being competitive for a
long time to come.

2.2.13.6 Emulation principle:

Take the best of at least three competitor's technologies in product design, development and production.

There is often a reluctance on the part of many companies (particularly in the US) to emulate the designs and production methods and management styles of foreign competitors. At the other extreme, there are many companies, particularly in the Far East, that have copied the technological know-how of many Western companies.

2.2.13.7 Productivity gains-sharing principle:

Always share the gains in productivity improvements with everyone directly or indirectly responsible for it, particularly employees and customers.

This principle is one of the most important, and yet, perhaps, one of the most neglected, hindering rapid and consistent productivity gains in organizations.

An organization that improves the level and growth rate of its productivity must be sincerely searching for ways to distribute the gains of employees, customers, stockholders, vendors, and distributors. Many so-called productivity improvement programs fail because this principle is violated, particularly with reference to employees and customers.

Companies that have had successful productivity programs have not only operated at price increase less than those in the industry but have done so at increased wages and salary rates to their employees. True productivity improvement must manifest itself this way, and the gains from it must be shared with those who are responsible for it. The idea of productivity gain sharing should not be viewed as "socialism," but rather as fair and just practice toward successful organizational management.

2.2.13.8 Leading competitor principle:

Be the leading competitor for as many products/services as possible.

The underlying assumptions behind this principle is that those companies that have more leading-edge products or services tend to be the leading competitors in the market. Of course, the sustenance of the leading edge is very much dependent upon the efforts to maintain such an edge over the competitors. An organization that is a leading competitor in many products or services has a greater safety cushion in the marketplace than those that do not.
Companies that produce their products "right - the first time" offer the best quality product at the most competitive price have a much better chance of being leading competitors.

2.2.13.9 Harmony principle:

Seek harmony in human relations at all levels of management from the topmost executive down to the production/operations level employee.

This is probably one of the most difficult principles to practice, yet it is the most effective one for both short- and long-term productivity improvement. Internal politics in an organization result from lack of harmony between the goals and objectives of the management, the employees, and the unions. Wherever a union exists, sincere efforts must be made to work with it.

2.2.13.10 International outlook principle:

Keep an international perspective in management activities related to planning, research and development, marketing, operations / production, and technology transfer.

An organization need not wait to practice this principle until it has become a multinational operation. By keeping track of the technological, economic, and political developments in other countries - both the so-called "developed and developing" - management can better plan the various aspects of their activities.

Because of the increasingly complex and interdependent nature of today's world, organizations cannot afford to have tunnel vision in what they do. If an organization likes to call itself the "leader" in the products or services it offers, it should strive to justify that title. A leader has to constantly keep abreast of the developments in the international arena if the competitive edge is to be maintained.

Several actions can be taken in this regard. Organizations should try to:

* have a small group of people at the corporate level to gather information from various parts of their competitive environment on products, processes, market shares, technological developments, etc.
* apply "game theory" to determine the long term strategies for productivity improvement.
* make vital information available to the various divisions and plants or operations centers in the corporation.

2.2.13.11 Co-operative research principle:

Work closely with universities and generic research establishments to bring in ideas for productivity improvement.
By practicing this principle, organizations should be able to obtain and implement many new ideas for productivity improvement at a lower cost than if they conducted all the research by themselves.

Universities can offer many opportunities for co-operative research. Student interns at both the senior undergraduate and graduate levels are a source of fresh thinking and new ideas that may otherwise have to be purchased through consultant services. University faculties can conduct valuable research - application oriented as well as basic type - at a much lower cost than other means. Also, generic research establishments that are funded by government grants are excellent places to be associated with for the state-of-the-art technologies. e.g., in the US, these are known as COGENT (Cooperative Generic Technology) Centers, where each center is developing generic technologies in a specific area such as tribology, welding, etc.

2.2.13.12 Productivity process principle:

Productivity improvement must be an ongoing, day-to-day process and not a one-time program or project. Human beings, in general, and organizations, in particular, have a tendency to join the bandwagon whenever a new concept is introduced, without truly analyzing its relevance to their systems. Zero-defects programs were popular at one time, then they died down, and now they once again seem to be in vogue. Quality circles is another concept companies are embracing at a phenomenal rate, because the Japanese used it to capture the international markets.

Productivity improvement must continue regardless of the amount of publicity the term "productivity" receives. In any organization, whether profit making or not, there is always a need to offer the best product or service at the lowest possible cost of manufacture or the lowest possible cost of delivery of the service. Only consistent, honest efforts at productivity improvement can ensure this result, irrespective of the importance associated with the term "productivity". The productivity process must be as much a routine in an organization as the manufacturing, selling and accounting functions are.
2.2.14 PRODUCTIVITY CULTURE OF ORGANIZATIONS:

The foregoing managerial style, and policies, over time lead to the creation of a powerful culture supportive of productivity in an organization. An organization's productivity culture represents an extremely valuable asset of competitive import.

The specific content of the dominant beliefs i.e. culture of the excellent companies, includes just a few basic shared values as follows:

1. A belief in the "best".
2. A belief in the importance of the details of execution.
3. A belief in the importance of people as individuals.
4. A belief in superior quality and service.
5. A belief that most members of the organization should be innovators & its corollary, the willingness to support failure.
6. A belief in the importance of informality to enhance communication, and
7. An explicit belief in and recognition of, the importance of economic growth and profits.

2.2.15 BUILDING OF PRODUCTIVITY CULTURE:

Managements of enterprises build, sustain and strengthen their organization's productivity cultures in the following ways:

1. Creating, diffusing and sharing a vision of organization's mission and future.
2. Communicating openly, clearly, and persuasively, toward securing and sustaining shared perceptions and undertaking.
3. Providing an environment of supportive, trusting, & authentic interpersonal relationships.
4. Exhorting, & coaching, toward high standards of achievement and performance.
5. Praising and recognizing accomplishments through symbols, rituals, and ceremonies.
6. Resolving conflicts skillfully through its accumulated resources of mutual trust, goodwill and respect.
7. Tolerating failures, and praising dedicated work involved in the failed efforts, toward innovation.
8. Balancing uncompromising standards, and high expectations with sympathy, understanding, and help.
9. Reconciling creativity with resource constraints.

10. Matching the breadth of vision with attention of details.

Organizations' productivity culture provides the benevolent ambience, within which innovative individuals are enabled to orchestrate their creativity by organizing the flow of communication, resources, and cooperation around it. Building a strong, and integrative culture supportive of productivity, and innovation, is the first and foremost condition for an organization's effective steering toward the goal of productive excellence.

2.2.16 A COMPREHENSIVE SET OF PREMISES FOR ORGANIZING PRODUCTIVITY IMPROVEMENT PROGRAMMES:

The foregoing six sets of guidelines are broadly similar in their orientation, though there are some important differences in their respective details. The fourteen guiding principles specified by Deming, and the ten basic factors for success postulated by Edosonwan, together provide an inclusive set of guiding principles for organizing productivity, and quality improvement programmes in industrial enterprises. A more comprehensive and non-redundant set of organizing premises, based on all the foregoing six paradigms may be briefly specified as follows. There is no particular order or sequence in their listing.

1. Top management support for the programme through policies and practices.

2. Specification of programme objectives and policies consistent with organization goals.


4. Prioritization of the productivity-quality improvement goals during that period.

5. Preparation of action plans/projects for realization of goals or problem-solving.


7. Information system & database for the programmes' management.

8. Productivity improvement work to be aligned at both the task level and the organization level.

9. Documentation of projects and their results.

10. Alignment of productivity projects with organization's strategy and planning.

11. Attuning of productivity - quality improvement work with the needs of customers and market.
12. Small groups / teams of persons drawn from same or different functional areas for projects.

13. Voluntary participation in teams.

14. Autonomous or self-managed nature of work groups / teams.

15. Procedures for project selection and management.

16. Periodic and regular training of management and employees for directing and implementing improvement tasks and projects.

17. Follow up action on team's recommendations and feedback to team members.

18. Documentation of process parameters.


20. Creation of structure & systems for productivity improvement programs.

21. Productivity quality improvement as a regular continuous activity.

22. Recognition & reward mechanisms for successful project work.

23. Participative management style.

24. Openness of communication across functional departments & levels

25. Motivation and commitment of employees at all levels.


27. Managers as exemplars and role models. They should communicate values and high expectations.


29. Diffusion of organization-wide consciousness of productivity and quality issues.

30. Extensive cooperation between functional departments for program implementation and problem-solving.

31. Continuous work focus on systems i.e. design materials, components, machines, maintenance, tools, training and process

32. Work standards emphasizing numerical quotas to be abandoned.

33. Overall monitoring of the program as a whole in a regular manner.

Organization of a productivity improvement program, besides its organizing premises, also requires a framework of structure and functions, for the programmers' implementation. Structure is the means for carrying out the functions of the program, and translating its guiding premises into action. Such a framework of structure and functions, for program implementation, is desired.
2.3 REVIEW OF THE LITERATURE:

A perspective for the research is established in this Chapter by reviewing the relevant lot sizing literature, classifying the work by problem characteristics. Several examples of the procedures currently used for lot sizing in inventory control systems are given.

The literature dealing with single-level sizing is discussed.

2.3.1 CHARACTERISTICS OF LOT SIZING PROBLEMS:

Several researchers have published recent articles surveying the lot sizing literature, including Krajewski, Prout and Clark. Each offers his own problem classification scheme. The following framework is a synthesis of these three approaches. Lot sizing problems can be classified according to:

1. The number of levels
2. The number of end items
3. The continuity of demand
4. Whether backlogging is allowed
5. Whether production capacity or other resources are constrained and;
6. Which production and control system is used.

Additional characteristics of lot sizing problems are mentioned where appropriate within the discussion of the major characteristics.

2.3.1.1 Number of Levels:

This characteristic refers to the stages in the manufacturing system. Some researchers use the term echelon to refer to a level. It is assumed that at each level, there is a part or component that may be inventoried. There are two major categories for this characteristic: single level and multi-level. Single level lot sizing problems involve determining the planned orders for a single part, the demands for such parts are determined externally. In multi-level lot sizing problems, the planned orders and requirements for the parts are linked through the dependent demand concept.

2.3.1.2 Number of End Items, Number of Parent Parts:

This characteristic refers to the number of finished goods for which we have assembly schedule. Again there are two categories for this characteristic: single end items and multiple end items. A finer subdivision may similarly be
made for multi-level lot sizing problems. A subpart may have a single parent part or it may have multiple parent parts. Figure shows several examples of this characteristic. A parent part may occur at any level in the product structure. Typically, a part will be a subpart of its parent part & is a parent part for its own subparts. Thus, a characteristic attributable to a parent part would apply to any parent part, whether it is also a subpart or not.

2.3.1.3 Continuity of Demand:
The demand for a particular part may be discrete or continuous. With continuous demand, units are removed from a part's inventory gradually throughout a period. With discrete demand, the part's inventory is depleted at the beginning of the period. The difference between these two cases lies in the timing of the demand. A further distinction within the discrete demand case is made between constant demand and lumpy demand for a part. Lumpiness of demand refers to the variation in demand from period to period.

2.3.1.4 Certainty of Demand:
Forecasting error is often a critical factor in the lot sizing problem. We can describe demand as being either deterministic or stochastic. With deterministic demand, there is no forecast error. The stochastic category includes all cases where there is uncertainty in the demand.

2.3.1.5 Backlogging:
Backlogging or back orders for parts may or may not be allowed. A backlog is created whenever the inventory of a part is not sufficient to meet the demand for that part. Even though management may not desire backlogs, still they may occur due to unforeseen circumstances. However, this characteristic really refers to planned backlogs, where a backlog is knowingly created when the lot size decisions are made. If no backlogging is allowed, all production lots must be chosen to insure feasibility, since timely production of a parent part depends on having sufficient quantities of all constituent parts available. If backlogging is permitted, a component is partially completed and stored in this form until the backlogging constituent parts are available. A distinction is sometimes made for the level at which backlogs are allowed. It is usually required that the master schedule be met without backorders.

2.3.1.6 Constrained Production Resources:
This characteristic refers to the manufacturing plant's ability to fabricate or assemble a given quantity of a part within the given lead time. Capacity is either limited or not limited. With unlimited capacity, planned backlogs are unlikely. One case where production resources are constrained involves the utilization of a single manufacturing facility for
several parts. The capacity of the machine may be sufficient for each part individually, but interference between parts can introduce capacity constraints to the system.

2.3.1.7 Materials Requirements Planning:

The use of MRP as the production planning and inventory control tool constitutes another characteristic of lot sizing problems. Before computerized versions of MRP or similar tools were available, the predominant production planning and control systems were collectively called order point systems. In fact, this type of system is still used by a majority of manufacturing companies. Because more and more firms are adopting MRP systems, it is important to consider lot sizing rules for this type of system.

2.3.1.8 Characteristics of the Research Problem:

The lot sizing problem examined in this research has the following characteristics. We consider single-level lot sizing problems where there is a single end item. We examine product structures in which each part has only a single parent part. Demand is discrete and deterministic, but may be lumpy. Backlogs are not allowed at any level in the system and production capacity is assumed to be unlimited.

While the MRP time-phasing logic can easily offset planned orders and gross requirements to account for non-zero lead times, lead times for all parts are set at zero periods, in order to keep the length of the planning horizon as short as possible, lead times should be kept as small as possible. A shorter planning horizon reduces the computational burden of the simulation experiment, both from a computing time and from an information requirement basis.

Material requirements planning is used as the production planning and control tool. It is assumed that there is no independent demand for any of the parts in the system and that all requirements are derived from the end item master schedule.
2.3.2 GROWTH VIS-A-VIS SICKNESS IN SMALL SCALE INDUSTRIES IN INDIA:

The small scale industries have registered an impressive growth over the years. Their number has grown from 4.2 lakhs in 1973-74 to about 20 lakhs in 1990-91 i.e. a five fold increase within two decades. Similarly, while production has registered an increase of more than 20 times, employment grew by about 3-times during 1974-92.

Growth in exports has been commendable from a mere Rs. 393 crores in 1973-74 to a record high of Rs. 12,658 crores in 1991-92 - a very significant feature being the growing share in non-traditional exports (S.S. Khanka, 1994). Thus, high and impressive rate of growth of the SSIs sector holds good promise for India's industrial development in particular, and economic development in general. The growth in employment strengthens the belief that absorption of surplus labor can take place in the SSI sector, to a significant extent. If a push is given to this growing and promising sector, it can become a stabilizing factor in a capital scarce economy like India by providing a higher output capital ratio as well as a higher employment capital ratio.

Table 2.8: Indicators of growth in small scale sector:

<table>
<thead>
<tr>
<th>Years</th>
<th>Production (Rs. Crores)</th>
<th>Employment (Lakhs Number)</th>
<th>Exports (Rs. Crores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973-74</td>
<td>7,200</td>
<td>39.7</td>
<td>393</td>
</tr>
<tr>
<td>1977-78</td>
<td>14,300</td>
<td>54.0</td>
<td>845</td>
</tr>
<tr>
<td>1980-81</td>
<td>28,060</td>
<td>71.0</td>
<td>1,643</td>
</tr>
<tr>
<td>1985-86</td>
<td>61,228</td>
<td>96.0</td>
<td>2,769</td>
</tr>
<tr>
<td>1986-87</td>
<td>72,250</td>
<td>101.4</td>
<td>3,648</td>
</tr>
<tr>
<td>1987-88</td>
<td>87,300</td>
<td>107.0</td>
<td>4,373</td>
</tr>
<tr>
<td>1988-89</td>
<td>106,400</td>
<td>113.0</td>
<td>5,490</td>
</tr>
<tr>
<td>1989-90</td>
<td>132,320</td>
<td>119.6</td>
<td>7,626</td>
</tr>
<tr>
<td>1990-91</td>
<td>157,550</td>
<td>126.2</td>
<td>9,100</td>
</tr>
<tr>
<td>1991-92</td>
<td>160,000</td>
<td>126.0</td>
<td>12,658</td>
</tr>
</tbody>
</table>

(Source: Small Industries Development Organization and Eighth Five Year Plan 1992-97.)

However, so far as the very high growth rates are concerned, two points need to be mentioned. First, the high growth rates in production, to a great extent, exaggerates the achievements since the figures of production are at current prices and thus, conceal the impact of inflation on rise in production. This is well supported by the fact that the production at 1970-71 prices was Rs. 5,161 crores in 1973-74 and Rs. 17,840 crores in 1985-86 i.e. far less than the respective production at 1994-95 prices (S. S. Khanka, 1994). Second, much of the growth is brought about by the
definitional change of SSI from time to time. Since 1973-74, the upward revision of the investment ceiling, has undergone changes in 1975, 1980, 1985 and 1991. As a result, a good number of erstwhile large and medium scale units shifted to the category of SSI. Inevitably, the growth rate of SSI sector has been faster both in terms of output and employment. Presently, the output - employment ratio for the small sector sector is 1:1.4 (S S Khanka, 1994)

2.3.3 GROWING SICKNESS IN SMALL SCALE INDUSTRIES:

A small scale unit is sick when its accounts with banks are irregular continuously for six to nine months, erosion of capital takes place at the rate of more than 10% per annum, there is continuing default in the payment to the creditors and the unit has remained closed for the previous six months. In simple words, sickness refers to a firm performing worse than the average, not covering its fixed costs, and frequently reneging on its debt repayment obligations.

Global experience indicates that in the process of economic and industrial development, a certain level of industrial sickness is inevitable as the inefficient units are bound to be displaced from the industrial scene by more efficient ones. For instance, in United Kingdom, more than 10,000 industrial units are estimated to fall every year with nearly 20% of the firms listed on the stock exchanges turning sick each year (Slatter, 1984). During the period 1972 to 1983, the number of bankruptcies per annum increased from around 10,000 to more than around 25,000 in United States, from less than 7,000 to around 20,000 in Japan, from around 4,000 to more than 10,000 in West Germany and from 3,000 to more than 12,000 in the United Kingdom (Khambadkone and Stallworthy, 1985). But, sickness in the Indian industries has grown rapidly in the recent years and has assumed alarming proportions, the number of sick units has increased by more than 8-times (81%) from 24,550 sick units in 1980 to 2,23,809 in 1991. The industry-wise break up of increase in sick units is noteworthy. During the period 1980-91, while non-SSI sick units experienced an increase of 67% only, from 1,401 to 2,337 units, SSI sick units recorded an increase of the order of 857% from 23,149 to 2,21,472 units. Thus, sickness has become endemic particularly in the small sector in India.

In a study of growth in sickness in SSIs, it seems pertinent to make a comparative analysis between the growth of SSI units vis-a-vis the growth of sick small units. Table 2 shows the relevant data. A close look at the figures on the total small scale units and sick units during 1977-91 clearly reveals that both have experienced steady growth during the period. The growth of sick small units far exceeds the growth of small scale units whether indicated by the ratio of sick units to total units, annual growth rates or compound growth rates during the period 1977-91. It is also noticed that the incidence of sickness in small units assumed alarming proportions during the eighties.
Till 1981, the ratio of sick small units to total small units trailed at 1:20 only. But, it reached 1:5 by 1988. It is, of course, a happy augury that the incidence of sickness in small units has tended to decline for the first time in 1990 probably due to the positive impact of the New Economic Policy. Yet, out of every 10 small units 1 is sick.

Table 6: Growth of sickness on small scale industries

<table>
<thead>
<tr>
<th>Year</th>
<th>Total small units</th>
<th>Sick small units</th>
<th>(2^{1/2}) (%) increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number %increase</td>
<td>Number %increase</td>
<td>(%) increase</td>
</tr>
<tr>
<td>1977</td>
<td>2,95,720 --</td>
<td>16,730 --</td>
<td>5.66</td>
</tr>
<tr>
<td>1978</td>
<td>3,33,837 12.89</td>
<td>18,950 13.27</td>
<td>5.68</td>
</tr>
<tr>
<td>1979</td>
<td>3,91,750 17.34</td>
<td>20,975 10.69</td>
<td>5.35</td>
</tr>
<tr>
<td>1980</td>
<td>4,47,821 14.31</td>
<td>23,149 10.36</td>
<td>5.17</td>
</tr>
<tr>
<td>1981</td>
<td>5,23,185 16.83</td>
<td>25,342 9.47</td>
<td>4.84</td>
</tr>
<tr>
<td>1982</td>
<td>6,07,049 16.03</td>
<td>58,551 13.04</td>
<td>9.64</td>
</tr>
<tr>
<td>1983</td>
<td>6,87,295 13.22</td>
<td>78,363 33.84</td>
<td>11.40</td>
</tr>
<tr>
<td>1984</td>
<td>7,57,092 10.15</td>
<td>91,450 16.70</td>
<td>12.08</td>
</tr>
<tr>
<td>1985</td>
<td>8,54,843 12.91</td>
<td>1,17,789 28.80</td>
<td>13.78</td>
</tr>
<tr>
<td>1986</td>
<td>9,50,334 11.17</td>
<td>1,45,776 23.76</td>
<td>15.34</td>
</tr>
<tr>
<td>1987</td>
<td>10,48,253 10.30</td>
<td>2,04,259 40.12</td>
<td>19.48</td>
</tr>
<tr>
<td>1988</td>
<td>11,58,765 10.54</td>
<td>2,40,573 17.78</td>
<td>20.76</td>
</tr>
<tr>
<td>1990</td>
<td>19,40,000 67.41</td>
<td>2,18,828 -9.04</td>
<td>11.28</td>
</tr>
<tr>
<td>1991</td>
<td>20,00,000 3.09</td>
<td>2,21,472 1.21</td>
<td>11.07</td>
</tr>
</tbody>
</table>

Compound growth rate 14.41% 21.86%

1977-91

(Source: 1. State/Union Territory Directory of Industries
2. Economic Survey of respective years, Govt. of India, Ministry of Finance, Economic Development.)

Not only has sickness spread to a large number of industrial units, but the incidence of sickness has also advanced to an extreme from making the majority of the units non-viable. A sick industrial unit is regarded as potentially viable, if, in the opinion of the banks assessing its viability, it would be in a position, after implementing a package of concessions spread over a period not exceeding seven years from the commencement of the package, to continue to service its repayment obligations as agreed upon, including those formulated part of the package without the help of any further concessions after the aforesaid period. Information on the viability status of the sick small scale units relating to the period 1987-91 is in Table 6.

Table 7: Viability status of sick small scale units.

<table>
<thead>
<tr>
<th>Description</th>
<th>June 1987</th>
<th>March 1990</th>
<th>March 1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of sick units</td>
<td>2,04,259</td>
<td>2,18,828</td>
<td>2,21,472</td>
</tr>
<tr>
<td>Number of units for which viability assessment has been made</td>
<td>1,99,318</td>
<td>2,16,543</td>
<td>2,19,138</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>No. of units found viable</td>
<td>12,484</td>
<td>16,451</td>
<td>16,140</td>
</tr>
<tr>
<td>No. of units found non-viable</td>
<td>1,86,834</td>
<td>2,00,092</td>
<td>2,02,998</td>
</tr>
<tr>
<td>% of viable units to total sick units</td>
<td>6.1</td>
<td>7.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Outstanding bank credit for units found viable (Rs. Crores)</td>
<td>359.50</td>
<td>390.50</td>
<td>693.10</td>
</tr>
<tr>
<td>Units under nursing program</td>
<td>8,470</td>
<td>12,160</td>
<td>13,224</td>
</tr>
<tr>
<td>% of units under nursing program total viable units</td>
<td>67.8</td>
<td>73.9</td>
<td>79.4</td>
</tr>
</tbody>
</table>

(Source: Ministry of Finance, Govt. of India, Economic Survey of respective years.)

The growing incidence of sickness in Indian industry has become all pervasive in terms of ownership, across scale (small, medium and large), States and industries. The statewise distribution of industrial sickness is presented in Table C:

Table C: Statewise distribution of small scale units vis-a-vis sick small scale units.

<table>
<thead>
<tr>
<th>States</th>
<th>1989</th>
<th>% (of 3 to 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of SSI units</td>
<td>No. of sick SSI units</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>70,149</td>
<td>21,461</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>86,499</td>
<td>10,105</td>
</tr>
<tr>
<td>Gujarat</td>
<td>65,553</td>
<td>6,302</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>54,610</td>
<td>14,497</td>
</tr>
<tr>
<td>Karnataka</td>
<td>62,534</td>
<td>8,318</td>
</tr>
<tr>
<td>West Bengal</td>
<td>1,31,656</td>
<td>25,648</td>
</tr>
<tr>
<td>Bihar</td>
<td>59,886</td>
<td>5,250</td>
</tr>
<tr>
<td>Orissa</td>
<td>16,061</td>
<td>4,486</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>1,38,729</td>
<td>14,675</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>1,45,797</td>
<td>24,401</td>
</tr>
<tr>
<td>Punjab</td>
<td>96,519</td>
<td>4,467</td>
</tr>
<tr>
<td>Haryana</td>
<td>61,229</td>
<td>2,179</td>
</tr>
</tbody>
</table>

56
Rajasthan  56,761  11,925  21.01
Kerala    30,178  17,021  56.40 ($, $)
Others    64,464  17,706  27.47

All India 11,58,765 1,86,441 16.09


The latest data available on industry-wise distribution of sick units as at the end of September 1989 indicates that sickness is an industry phenomenon also. It can be seen from Table 2 that four industry groups viz. engineering and electricals, textiles, chemicals, iron and steel accounted for 27% and 46% of the total sick SSI units and outstanding bank credit respectively. These four groups are followed by paper and rubber industries in that order.

<table>
<thead>
<tr>
<th>Table 2: Industry wise classification of sick small scale units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Industry</strong></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Engineering &amp; Electrical</td>
</tr>
<tr>
<td>Iron &amp; steel</td>
</tr>
<tr>
<td>Textiles</td>
</tr>
<tr>
<td>Chemicals</td>
</tr>
<tr>
<td>Sugar</td>
</tr>
<tr>
<td>Jute</td>
</tr>
<tr>
<td>Rubber</td>
</tr>
<tr>
<td>Cement</td>
</tr>
<tr>
<td>Paper</td>
</tr>
<tr>
<td>Other industries</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

2.3.4 PRODUCTIVITY LEVELS OF MANUFACTURING SECTOR IN SELECTED ASIAN COUNTRIES:

India has a fairly large base of manufacturing industries. Though Indian industries are familiar with the techniques of corporate planning and strategic planning concepts of competitive strategy and competitive advantages at a specific product market level have not been much popular mostly on account of lack of competition in most of the manufacturing industry, mostly dominated by private sector units along with some multinational firms. Marketing of brands, evolving new brands, market segmentation, etc., are some of the market related strategic approaches followed by Indian organizations. Manufacturing which is normally visualized as a supporting function to these marketing oriented strategies never have received explicit recognition of its contributions to the development of competitive advantage, manufacturing function in most of the industries including consumer goods has been found always in a state of fire fighting towards fulfilling targets of time, cost and quality. As a result, labor productivity level and productivity growth rate in Indian manufacturing sector as a whole has been low compared to those in many other Asian countries as shown in Figure. Many of the firms may lose even in the domestic market unless manufacturing function as "equivalent to doing" is considered while planning for a product market strategy. After all, it is the execution i.e. production and delivery which ultimately provides satisfaction to customers and thereby, the competitive advantages of the firm get manifested in terms of higher sales and lower costs.

2.3.5 CAPITAL PRODUCTIVITY AMONG STATES IN INDIA:

Capital productivity indices for 10 States for all industries together for the years 1980-81, 1984-85 and 1989-90 are summarized in Table. The capital productivity has marginally increased for India as a whole. The state with the highest capital productivity was Maharashtra in 1980-81. Tamil Nadu in 1984-85 and Maharashtra again in 1988-89.

Table: Statewise capital productivity

<table>
<thead>
<tr>
<th>State</th>
<th>Capital Productivity (CP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>0.1962</td>
</tr>
<tr>
<td>Bihar</td>
<td>0.1074</td>
</tr>
<tr>
<td>Gujarat</td>
<td>0.2449</td>
</tr>
<tr>
<td>Karnataka</td>
<td>0.2644</td>
</tr>
</tbody>
</table>
Productivity levels of manufacturing sector in selected Asian Countries (1990)
Madhya Pradesh  0.1938  0.1633  0.2446
Maharashtra  0.3458  0.3398  0.3464
Punjab  0.1876  0.1894  0.1765
Tamil Nadu  0.3131  0.3594  0.2873
Uttar Pradesh  0.1644  0.1600  0.2082
West Bengal  0.3242  0.2884  0.2313
All India  0.2413  0.2595  0.2605

(Source: Vora, 1994.)

Capital productivity for major selected industries increased from 1980-81 to 1984-85. However, during the period 1984-85 and 1988-89 capital productivity declined in manufacture of food products, beverages, tobacco and its products, chemicals and chemical products, and manufacture of electrical machinery, apparatus, appliances, supplies and parts. There was a consistent decline in capital productivity of the other industries group.

(Table: Industry wise capital productivity)

<table>
<thead>
<tr>
<th>Type of industry</th>
<th>1980-81</th>
<th>1984-85</th>
<th>1988-89</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacture of food products</td>
<td>0.2632</td>
<td>0.3544</td>
<td>0.3353</td>
</tr>
<tr>
<td>Manufacture of beverages, Tobacco and tobacco products</td>
<td>0.4812</td>
<td>0.6849</td>
<td>0.6101</td>
</tr>
<tr>
<td>Manufacture of rubber, plastic, petroleum and coal products</td>
<td>0.2183</td>
<td>0.2401</td>
<td>0.3379</td>
</tr>
<tr>
<td>Manufacture of chemicals and Chemical products</td>
<td>0.2295</td>
<td>0.3015</td>
<td>0.2851</td>
</tr>
<tr>
<td>Basic metal and alloy industries</td>
<td>0.1692</td>
<td>0.1561</td>
<td>0.2279</td>
</tr>
<tr>
<td>Manufacture of Electrical Machinery, apparatus, appliances, Supplies and parts</td>
<td>0.3992</td>
<td>0.5389</td>
<td>0.4179</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.1021</td>
<td>0.1078</td>
<td>0.1192</td>
</tr>
<tr>
<td>Other industries</td>
<td>0.4338</td>
<td>0.3997</td>
<td>0.3371</td>
</tr>
<tr>
<td>All industries</td>
<td>0.2413</td>
<td>0.2595</td>
<td>0.2605</td>
</tr>
</tbody>
</table>

(Source: Productivity: 1994.)
2.3.6 WASTEFUL PRACTICES IN INDIAN MANUFACTURING:

Value is added to a product when the product undergoes a transformation. However, in some cases, the transformation of a product can be value added. A distribution or a courier company e.g., adds value by bringing the product closer to the customer. In general, value is added to a product when a transformation process is perpetrated or when a product is brought closer to the customer. All operations which cannot be included in these two classes are wasteful and must be avoided or reduced to a minimum e.g., inspections, queues, transport between workstations, drawings waiting to be finished in a CAD system, orders waiting for release, …). The first step in the elimination of waste is identification. All the activities must be described and divided into a detailed time scheme. Every operation is classified as value added or non-value added. Different methods can be used in this phase. Method and time studies (MTM, MOST, Work sampling) provide very detailed quantitative analyses of the activities. Qualitative methods like flowcharts and DFD (data flow diagrams), are very useful to describe processes and procedures. In most processes non-VAT time will be responsible for more than 95% of the total lead time.

Table 5 provides an overview of the different wasteful practices which are common to all manufacturing facilities.

<table>
<thead>
<tr>
<th>Table 5: Wasteful practices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inventories</strong></td>
</tr>
<tr>
<td>Over production</td>
</tr>
<tr>
<td>Batch processing</td>
</tr>
<tr>
<td>Warehousing locations</td>
</tr>
<tr>
<td>Individual incentive systems</td>
</tr>
<tr>
<td><strong>Materials Handling</strong></td>
</tr>
<tr>
<td>Transportation</td>
</tr>
<tr>
<td>Motion</td>
</tr>
<tr>
<td><strong>Quality</strong></td>
</tr>
<tr>
<td>Defects in process</td>
</tr>
<tr>
<td>Reduced yield</td>
</tr>
<tr>
<td>Inspection</td>
</tr>
<tr>
<td>Quality assurance</td>
</tr>
<tr>
<td><strong>Floor space</strong></td>
</tr>
<tr>
<td>Function-oriented layout</td>
</tr>
<tr>
<td>Raw materials warehouse</td>
</tr>
<tr>
<td><strong>Machine utilization</strong></td>
</tr>
<tr>
<td>Set up</td>
</tr>
<tr>
<td>Maintenance</td>
</tr>
<tr>
<td>Breakdown</td>
</tr>
<tr>
<td>Reduced speed</td>
</tr>
<tr>
<td><strong>Non-manufacturing activities</strong></td>
</tr>
<tr>
<td>Batch information processing</td>
</tr>
</tbody>
</table>

(Source: Gelders, Andreis, Leliven, 1993.)
2.3.7 STRATEGIES TO INCREASE PRODUCTIVITY

There are three basic strategies to increase productivity. In Figure 2.6, Strategy I aims at maintaining performance while reducing the use of resources. Principally, this strategy is applied in situations of stagnating and declining markets and strives towards the reduction of work staff, the amount of capital invested or the amount of material used. Thus, increasing productivity requires a reduced number of employees, which often leads to potential conflicts and loss of time due to the short and medium term inflexibility of input factors and the company's social goals.

Strategy II aims at increasing output with steady input. Due to various inflexible factors such as long-term contracts to purchase materials, irreversible decisions of investment and the size of workforce which cannot be adjusted at short notice. Output maximization seems to be the only possible way to increase productivity directly dependent on market cycles. Because of the usual practice of maintaining reserves in the form of qualitative and quantitative overcapacity, strategy II does not necessarily lead to the improvement of production processes, but must be considered as a tool to intensify efforts and utilize capacities.

Strategy III on the other hand, awakens the optimism and motivation of the organization by defining future oriented process targets. According to the changes in the evaluation of objectives and the integration of new partial objectives, the focus on produced quality as an output figure is abandoned. Productivity measures steering to business processes and relating them to market requirements are necessary to solve weaknesses within the enterprise. Productivity in this sense can be regarded as an effective and efficient fulfilment of market requiring within processes chains. These requirements have to be defined for each organizational unit and quantified within the scope of a cooperative target agreement. The conclusion that anything which is not measured will not be improved, is valid.

Although many companies have recognized these problems, the supporting and controlling systems are still oriented towards the traditional measurements. As management of the manufacturing sector is further measured by traditional productivity measures, it is not surprising that the changed objectives are not pursued consequently and permanently in the enterprise. (Wildemann, 1993).
Basic strategies to increase productivity

<table>
<thead>
<tr>
<th>Quantity-oriented strategy</th>
<th>characteristics:</th>
</tr>
</thead>
</table>
| strategy I \[ \frac{\text{output}}{\text{input}} \] = productivity \[ \uparrow \] | • neglecting process  
• limited individual planning  
• orientation on market and economic cycles  
• resistance to adaption  
• change of parameters |
| strategy II \[ \frac{\text{output}}{\text{input}} \] = productivity \[ \uparrow \] |

| Provedetierte Strategie | • optimization of process  
• continuous improvement  
• active strategy to gain competitive advantage  
• adaption of methods and structure |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>strategy III</td>
<td></td>
</tr>
</tbody>
</table>

- improvement of process
- increase of output
- gain of competitive advantage
2.3.8 PRODUCTIVITY INCREASE IN MATERIAL FLOW PROCESS:

The analysis of the term "productivity in the flow of material" starts with the market and customer requirements concerning the flow of material. These requirements consist of the consignment of agreed products in the right quantities and types at the right time. The term "customer" applies not only to the final buyer but also to the internal customers. The input factors for the flow of material processes are material stock, transport and storage area, transport capacity in the form of means of transport and personnel, material planning capacity for steering the flow of material as well as container and packing material. Transparency, utilization rate, flow rate, standardization rate and complexity rate are relevant as process factors in the flow of material. The performance figures for the output of the flow of material process is service rate, it is defined as the ratio between deliveries matching demand and the total number of orders. The performance figures ensure that the activities in the flow of material are consequently aimed at customer requirements. Increase in productivity is measured by the success factor time in contrast to simple quantities. Increase of process productivity in the flow of material is achieved by maximizing the delivery service rate proportion.

With an increase in the application of input such as inventories, space, transport and coordination capacity, the delivery service rate increases. At first, the delivery service rate grows progressively beginning at zero point, until it changes at point A into a digressive trend. The average ratio between delivery service rate to applied input has its maximum in point B. If the delivery service rate is not predetermined at another level by the market, the productivity target for the flow of material process could be found here. Normally, however, the delivery service rate is given by the market. Therefore, the objective is not a maximization of productivity, but the optimization of it by fulfilling the market requirements with an economical use of resources. It is important that the enterprises have to meet the different requirements according to industry, market situation, and product mix, regarding the delivery service rate. Therefore, productivity target must be defined according to individual requirements with an adjusted and corresponding flow of materials. Figure 6.4 shows that the delivery service rate starts to decrease at a particular critical input quantity. The increase of stock level within the production no longer leads to an improvement, but causes extended throughput times and a loss of short-run service flexibility.

The main tasks of productivity management concerning the flow of materials are the identification and realization of
Figure 2-8 8 - Relationship between input level and improvement activities.
the most economical material flow concept. Many companies are in the falling area of material flow function. If markets ask for an increased service level, companies often react incorrectly by increasing the input level, extended storage facilities, more transports and more coordination activity which raises cost and deteriorates efficiency in the flow of material. For most companies, the effective way to improve material flow productivity is to reduce the inputs level. By doing so, an improved input output relation is achieved on the input side and secondly, an improvement of the output is realized. This leads to a lower stock level, smaller storage facilities, reduction in transport containers controlling activities.

Figure 2.5 shows the connection between input level and improvement activities which had been determined through practice. Above a defined input level, there are no more improvement activities. Starting from a high level, the input has to be drastically reduced to start the improvement process. Starting from an extremely diminished input level, a small reduction of input results in a progressive increase of improvement activities. Deficits like complicated layouts, redundant handling activities, process difficulties, quality problems or lack of qualified workers become obvious and get corrected to achieve the desired service level. A small reduction of the input leads to a problem solving spiral according to the principles of continuous improvement.

**DISCUSSIONS:**

Due to the increasing dynamic and complexity of business, production is becoming more and more susceptible to process breakdown - not only of machinery, but also of logistics and production control. Many firms suffer from missing parts, wrong delivery or absent personnel. Therefore, another opportunity to increase productivity is to establish a breakdown management which refers not only to machine breakdown, but also to all deliveries from operating processes, such as logistics or purchasing.

European production strategies tend to buffer the effects of breakdowns. Safety stocks of material and added time are typical for this strategy. In contrast, Japanese strategies focus much more on the cause of breakdowns. Eliminating these causes results in lasting improvement of the production system and increased productivity by abolishing repeated activities and double work. A suitable approach to start the analysis is a flowchart of material. All breakdown accruing in the various processes affect the flow of material either by downtime or by inducing a change of original planning. All relevant data like the causes of a breakdown, its effects, the time, its location and the subsequent reaction has to be gathered. Data referring to orders is collected continuously by creating a data system.
Improvement spiral

- Recognition of problems
- Solve problems
  - Increasing effectiveness
  - Reducing complexity
  - Process standardization
  - Increasing flow-rate

- Increase delivery service rate
To sum up these arguments, three points have to be stressed. Productivity as a ratio of input to output is not automatically related to changing company goals. Due to the fact that modern markets require different performances in products and in services, productivity means more than simply maximizing the quotient of input and output in terms of mass production. Various performance indicators have to be integrated into a productivity analysis. Secondly, understanding productivity should shift focusing on the results of individual functions to focusing on different cross-functional business processes closely connected with market needs. In particular, processes in administrative departments should be integrated more closely. Finally, it is important to understand that there are different starting points to increase productivity. Reducing stocks or improving quality is the same mechanism which leads to improved productivity. The basic strategy is to eliminate all forms of waste by unbuffering the company.

2.3.9 A COMPARISON OF JAPANESE AND INDIAN SITUATION:
Table 2.4 summarizes the various attributes relevant to production systems in Japanese and Indian industries which demonstrate the differences in the two operating environments quite clearly.

Table 2.4: Comparison of attributes in Japanese and Indian Industries

<table>
<thead>
<tr>
<th>Category</th>
<th>Japanese Industry</th>
<th>Indian Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. People</td>
<td>a. Japanese workers:</td>
<td>Indian workers:</td>
</tr>
<tr>
<td></td>
<td>- cooperation, dedication,</td>
<td>Every man for thinking</td>
</tr>
<tr>
<td></td>
<td>harmony, group thinking,</td>
<td>himself.</td>
</tr>
<tr>
<td></td>
<td>decision process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Takes pride in the</td>
<td>Usually does not</td>
</tr>
<tr>
<td></td>
<td>company, high level</td>
<td>identify himself with</td>
</tr>
<tr>
<td></td>
<td>of motivation</td>
<td>company, comparative</td>
</tr>
<tr>
<td></td>
<td>lack of motivation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High literacy</td>
<td>Low literacy</td>
</tr>
<tr>
<td></td>
<td>Multifunctional</td>
<td>Specialized workers</td>
</tr>
<tr>
<td></td>
<td>workers</td>
<td></td>
</tr>
<tr>
<td>b. Enterprise union</td>
<td>Interaction between</td>
<td></td>
</tr>
<tr>
<td>(Japan is a homogeneous society)</td>
<td>the people at various</td>
<td></td>
</tr>
<tr>
<td></td>
<td>levels.</td>
<td></td>
</tr>
<tr>
<td>2. Plants</td>
<td>High level of automation, CAD/CAM</td>
<td>Very less automation</td>
</tr>
<tr>
<td></td>
<td>robotics used</td>
<td>CAD/CAM largely</td>
</tr>
<tr>
<td></td>
<td>Group technology</td>
<td>largely absent</td>
</tr>
<tr>
<td></td>
<td>present</td>
<td>Group technology</td>
</tr>
<tr>
<td></td>
<td>Autonomous machining</td>
<td>absent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Quality control

<table>
<thead>
<tr>
<th>100% inspection used</th>
<th>100% quality present</th>
</tr>
</thead>
</table>

Quality at the source, defect prevention produced, defect detection Absent

4. Production management

<table>
<thead>
<tr>
<th>KANBAN (pull system)</th>
<th>MRP (push system)</th>
</tr>
</thead>
</table>

Preventive maintenance 100% preventive maintenance absent

5. Product and its values

<table>
<thead>
<tr>
<th>Customer oriented product; provides real values</th>
<th>R &amp; D lacking. Product designs depend upon what is available rather than what the customer demands.</th>
</tr>
</thead>
</table>

Belief in long term low profit margin Strive for shorter term gains

(Source: Vrat, Mittal and Tyagi, 1993.)