Syllabus

Master of Business Administration (M.B.A.) 2nd Semester

206: Operation Management

Objective

The Course is oriented towards the exposition to the various operational problems in the area of production.

The Stress in the Course is on various techniques available for discharging the responsibilities as operations manager.

Course Contents:

UNIT-I

The Operations Managements System, Responsibilities of operations personnel, Basic Manufacturing Process-Continuous Intermittent and repetitive flaws of processing.

UNIT-II

Methods of forecasting Demand-Opinion Method. Time Series Analysis, Economic Indicators. Inventory Control-Costs associated with inventory control systems, Economic Order Quantity.

UNIT-III

The Production Control System for intermittent and continuous for processes. Project Scheduling PERT/CPM Method-Network analysis, earliest and latest time analysis. Gantt Charts.

UNIT-IV

Acceptance Sampling by Attributes-Single Sample, double sample and multiple sample plans with sales risk. Control Charts for variables-averages and ranges. Control charts for defectives- fraction defective and numbers defective.

UNIT-V

Work Study, Methods study and motivation study. Plant Layout concepts. Developing the process layout and the product layout. Facility location planning.

REFERENCES:

1. M.K. Star	Production Management System & Synthesis.
2. B.S. Butta	Modern Production Management.
3. Mayer	Production and Operations Management.
4. Lamar Le & D.W. Dobler	Purchasing and Materials Management.

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Chapter-1
Operations Management

Structure:

1.0 Learning objectives

After studying the lesson, you will be able to understand:-

- Operations Management concept
- Operations/ Production System Defined
- Historical Events in Operations Management
- Current Issues in Operations Management
- Strategies in Operations Management
- Contribution Operations management to the society

1.1. Introduction:

Operation is a function or system that transforms inputs into outputs of greater value. Through this process raw material is converted into semi finished products and thereby adds to the value of utility of products, which can be measured as the difference between the value of inputs and value of outputs.

Operation management function encompasses the activities of procurement, allocation and utilization of resources. The main objective of operation management function is to produce the goods and services demanded by the customers in the most efficient and economical way. Therefore efficient management of the production function is of utmost importance in order to achieve this objective.

Transformation process is a series of activities along a value chain extending from supplier to customer. Those activities that do not add value are superfluous and should be eliminated

1.2 Meaning and Concept of Operations Management

Operations Management is management of the conversion process which transforms inputs such as raw material and labor into outputs in the form of finished goods and services. Operation management involves design, operation, and improvement of productive systems. Operation management is also defined as the management of an organization's productive resources of its production system, which converts into the organization's products and services.

All organizations need to perform three basic functions namely, marketing, production/ operations and finance.

- Marketing: which generates demand or at least takes the order for a product or service
- Production/operations: which creates the product. Production is the creation of goods and services. Production/operation system is any system which transforms input into output and in the mean time creates value. In some organizations the product is a physical good (refrigerators, bread, etc.) and the activities creating such tangible product is usually referred to as Production. In others the product is a service (insurance, health care for elderly, etc.). The production that takes place to produce a service is called Operations.
- Finance/ Accounting: which tracks how well the organization is doing, pays bills, and collect the money

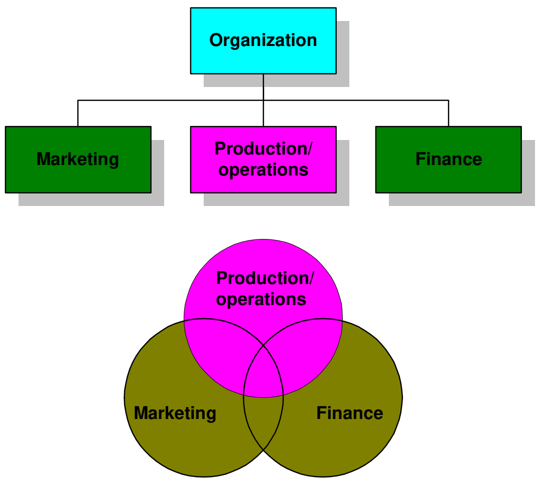


Figure: The three basic functions of business organizations

Operations management (OM) is defined as the design, operation, and improvement of the systems that create and deliver the firm's primary products and services.

Like marketing and finance, OM is a field of business with clear management responsibilities. This point is important because operations management is frequently confused with operations research and management science. The essential difference is that OM is a field of management whereas OR/MS is application of quantitative methods to decision making in all fields. Operations managers use the decision making tools of OR/MS (such as Critical path scheduling).

Figure 1.1. Transformation of inputs to outputs

Figure 1.2. Transformation of inputs to outputs by adding value

With either the broad or narrow view, managing operations is crucial to each area of an organization because only through successful management of people, capital, information, and materials can it meet its goals. While undertaking operations management functions, two principals must be considered;

i. Each part of an organization, not just the operation functions, must design and operate processes and deal with quality, technology, and staffing issues. Thus there has to be a synergy between different departments.

ii. Each part of an organization has its own identity and yet is connected with operations, i.e. there has to be coordination between departments and interdependence of different functions.

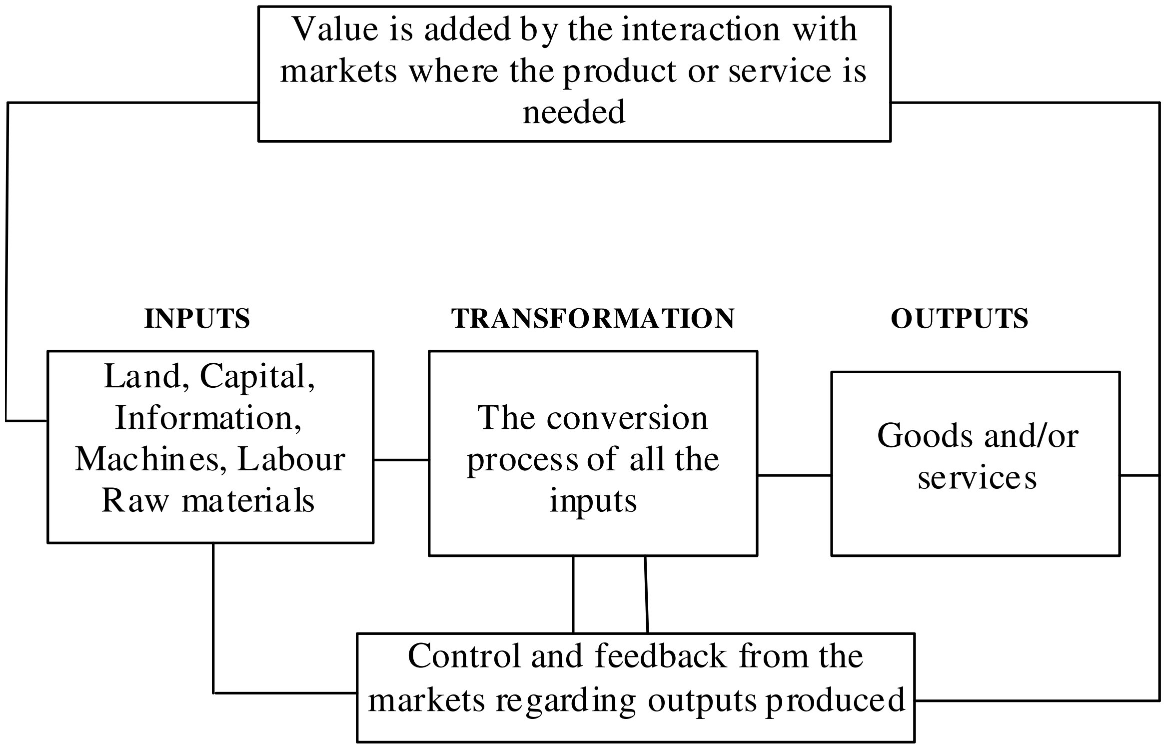


Figure 1.3. The transformation process – from inputs to outputs

Table 1.1. Examples of transformation processe

OPE-RATION	INPUTS	TRANSFORM PROCESS
Hospital	Doctors Nurses Patients	Beds Medicines Operations
Canned goods	Fresh foodstuff Machines Other equipment Labour	Prepare the food Can and cook th
Police	Officers Crime information Public Computers	Prevent crime Solve crime Arrest criminals
Food store	Foodstuffs for sale Staff Cash registers Customers	Display of goods Advise given Selling of goods

Table 1.2 Differences between the manufacturing and service industries

MANUFACTURING	SERVICE
A physical (tangible) product which is durable. The product may be used for many years.	An intangible product. This type of product is usually perishable. Can be used once only.
Goods produced can be stored in a warehouse or at home.	The final product cannot be stored.
No direct contact between consumer and producer.	By the nature of the service industry there must be direct contact.
Output is usually produced in large plants or factories.	Facilities for the service industry is usually much smaller.
Large capital outlays are required.	Very labour intensive operations.
Easy to determine and measure quality.	Much harder to determine and measure quality.
Not essential to be on the consumers doorstep. Goods can be transported.	Essential to be close to the consumer of the service rendered.
Output produced can be resold numerous times.	Cannot be resold to a third party.
Before consumption of the output can take place, it must be produced first.	Provision and consumption take place simultaneously.
The product produced can be patented.	It is difficult to patent the output.
Due to the low variability, production tends to be efficient and smooth.	The activities tend to be slow and awkward. Output is variable.
Productivity measurements tend to be straightforward.	Productivity measurements tend to be much more difficult.

Examples of manufacturing and service industries:

Manufacturing: Motor vehicles, bottling of beverages, canning of foodstuffs, manufacturing of household appliances and other electrical appliances.

Service: The following can be included: National, provincial and local government, financial services, cellular telephones and the servicing of motor vehicles.

Services can be further classified into two types; Core services and value added services. The core Services customers want the products that are made correctly, customized to their needs, delivered on time, and priced competitively.

Explicit services: Essential or intrinsic features of the service. Examples: smooth-running of motorbike after a tune-up; response time of a fire department

Implicit services: Psychological benefits of the service. Examples: certificate of a graduate degree from a well-known school, privacy of a loan office

1.3 Historical Events in Operations Management

Table 1.3 shows the historical events of Operations management.

The focus of this section is to highlight on major operations related concepts that have been popular since the beginning of industrial revolution. There were large number of developments as listed in the table including, the post civil war period, scientific management, human relations and behavioralism, operations research, the service revolution and the computer/ internet revolution.

Trends affecting the production and operations management are

- **Outsourcing**, increasing the importance of supply chain.
- **Globalisation**, internationalisation.
- Increasing **automatisation** at developed countries, moving towards a service economy
- **IT and ERP-system** evolution (which really is automatisation, too).
- **Flexible supply chains** for mass customization of products and services
- **Global supplier**, production, and distribution networks
- Commoditization of suppliers – "**plug compatibility**"
- **Enhancing value-added services**
- Maximizing **use of internet** to share information, coordinate production

Time Line for Operations Strategies

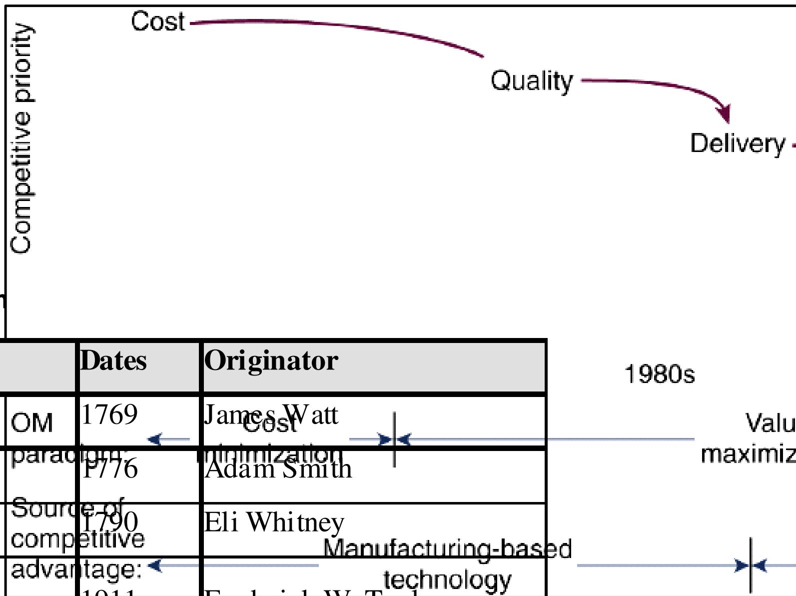


Table 1.3. Historical events of operations managem

Era	Events/Concepts	Dates	Originator
Industrial Revolution	Steam engine	1769	James Watt
	Division of labor	1776	Adam Smith
	Interchangeable parts	1790	Eli Whitney
Scientific Management	Principles of scientific management	1911	Frederick W. Taylor
	Time and motion studies	1911	Frank and Lillian Gilbreth
	Activity scheduling chart	1912	Henry Gantt
	Moving assembly line	1913	Henry Ford

Human Relations	Hawthorne studies	1930
	Motivation theories	1940s
		1950s
		1960s
Operations Research	Linear programming	1947
	Digital computer	1951
	Simulation, waiting line theory, decision theory, PERT/CPM	1950s
	MRP, EDI, EFT, CIM	1960s, 1970s
Quality Revolution	JIT (just-in-time)	1970s
	TQM (total quality management)	1980s
	Strategy and operations	1990s
	Business process reengineering	1990s

1.4. Just-In-Time (JIT) Production: The emerging trends

Just-in-time (JIT) is defined in the APICS dictionary as "a philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity". It also has been described as an approach with the objective of producing the right part in the right place at the right time (in other words, "just in time"). Waste results from any activity that adds cost without adding value, such as the unnecessary moving of materials, the accumulation of excess inventory, or the use of faulty production methods that create products requiring subsequent rework. JIT (also known as *lean production* or *stockless production*) should improve profits and return on investment by reducing inventory levels (increasing the inventory turnover rate), reducing variability, improving product quality, reducing production and delivery lead times, and reducing other costs (such as those associated with machine setup and equipment breakdown). In a JIT system, underutilized (excess) capacity is used instead of buffer inventories to hedge against problems that may arise.

JIT applies primarily to *repetitive manufacturing* processes in which the same products and components are produced over and over again. The general idea is to establish flow processes (even when the facility uses a jobbing or batch process layout) by linking work centers so that there is an even, balanced flow of materials throughout the entire production process, similar to that found in an assembly line. To accomplish this, an attempt is made to reach the goals of driving all inventory buffers toward zero and achieving the ideal lot size of one unit.

The basic elements of JIT were developed by Toyota in the 1950's, and became known as the Toyota Production System (TPS). JIT was well-established in many Japanese factories by the early 1970's. JIT began to be adopted in the U.S. in the 1980's (General Electric was an early adopter), and the JIT/lean concepts are now widely accepted and used.

1.4.1. Some Key Elements of JIT

1. Stabilize and level the MPS with uniform plant loading (***heijunka*** in Japanese): create a uniform load on all work centers through constant daily production (establish ***freeze windows*** to prevent changes in the production plan for some period of time) and mixed model assembly (produce roughly the same mix of products each day, using a repeating sequence if several products are produced on the same line). Meet demand fluctuations through end item inventory rather than through fluctuations in production level. Use of a stable production schedule also permits the use of ***backflushing*** to manage inventory: an end item's bill of materials is periodically exploded to calculate the usage quantities of the various components that were used to make the item, eliminating the need to collect detailed usage information on the shop floor.
2. Reduce or eliminate setup times: aim for single digit setup times (less than 10 minutes) or "one touch" setup this can be done through better planning, process redesign, and product redesign. A good example of the potential for improved setup times can be found in auto racing, where a NASCAR pit crew can change all four tires and put gas in the tank in under 20 seconds. (How long would it take you to change just one tire on your car?) The pit crew's efficiency is the result of a team effort using specialized equipment and a coordinated, well-rehearsed process.
3. Reduce lot sizes (manufacturing and purchase): reducing setup times allows economical production of smaller lots; close cooperation with suppliers is necessary to achieve reductions in order lot sizes for purchased items, since this will require more frequent deliveries.

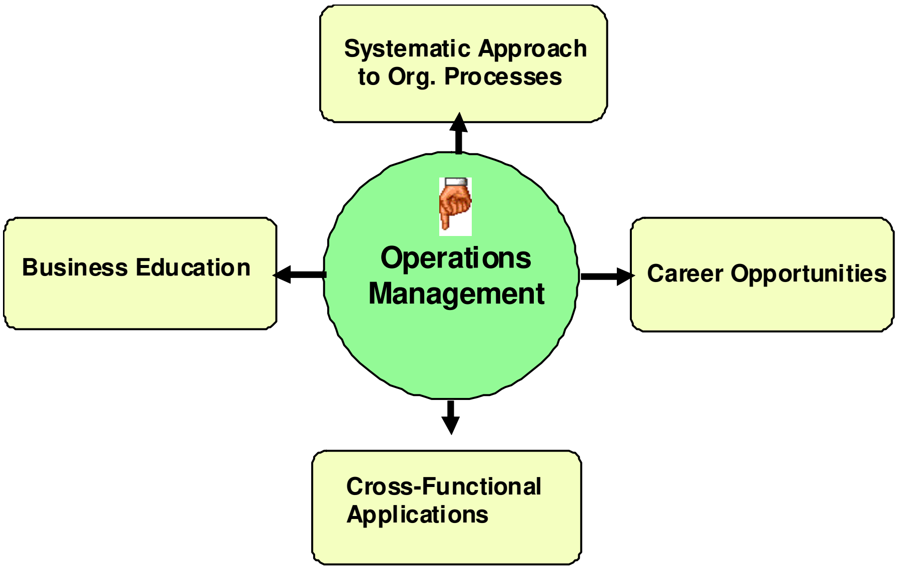
4. Reduce lead times (production and delivery): production lead times can be reduced by moving work stations closer together, applying group technology and cellular manufacturing concepts, reducing queue length (reducing the number of jobs waiting to be processed at a given machine), and improving the coordination and cooperation between successive processes; delivery lead times can be reduced through close cooperation with suppliers, possibly by inducing suppliers to locate closer to the factory.
5. Preventive maintenance: use machine and worker idle time to maintain equipment and prevent breakdowns.
6. Flexible work force: workers should be trained to operate several machines, to perform maintenance tasks, and to perform quality inspections. In general, JIT requires teams of competent, empowered employees who have more responsibility for their own work. The Toyota Production System concept of "respect for people" contributes to a good relationship between workers and management.
7. Require supplier quality assurance and implement a zero defects quality program: errors leading to defective items must be eliminated, since there are no buffers of excess parts. A *quality at the source* (***jidoka***) program must be implemented to give workers the personal responsibility for the quality of the work they do, and the authority to stop production when something goes wrong. Techniques such as "JIT lights" (to indicate line slowdowns or stoppages) and "tally boards" (to record and analyze causes of production stoppages and slowdowns to facilitate correcting them later) may be used.
8. Small lot (single unit) conveyance: use a control system such as a ***kanban*** (card) system (or other signaling system) to convey parts between work stations in small quantities (ideally, one unit at a time). In its largest sense, JIT is not the same thing as a kanban system, and a kanban system is not required to implement JIT (some companies have instituted a JIT program along with a MRP system), although JIT is required to implement a kanban system and the two concepts are frequently equated with one another.

1.5. Need and importance of studying Operations Management

- Marketing gets people to buy our product
- Finance makes sure we have the money to operate
- Accounting keeps track of what we spend
- Management keeps people on task
- I/S makes sure systems work to support everyone else
- Operations actually makes the thing we sell. Without operations, you can't have a company. Satisfying Customers depends on Operations managemnt

Objectives of production and operations management are how to efficiently provide the customer with

- the right amount of
- the right products & services at
- the right time.



1.6 Table 1.4. Major Decisions of Production & Operations Management

➢ Production control (monitoring) ➢ Chasing, expediting, fire fighting ➢ Production planning ➢ Production management ➢ Operations/Supply Chain management	➢ Materials planning ➢ Materials requirements planning (MRP) ➢ Manufacturing resources planning (MRP II) ➢ Enterprise resources planning (ERP) ➢ Advanced Planning & Scheduling (APS).

1.7 Scope of Operations Management

Figure 1.5. Scope of Operations Management

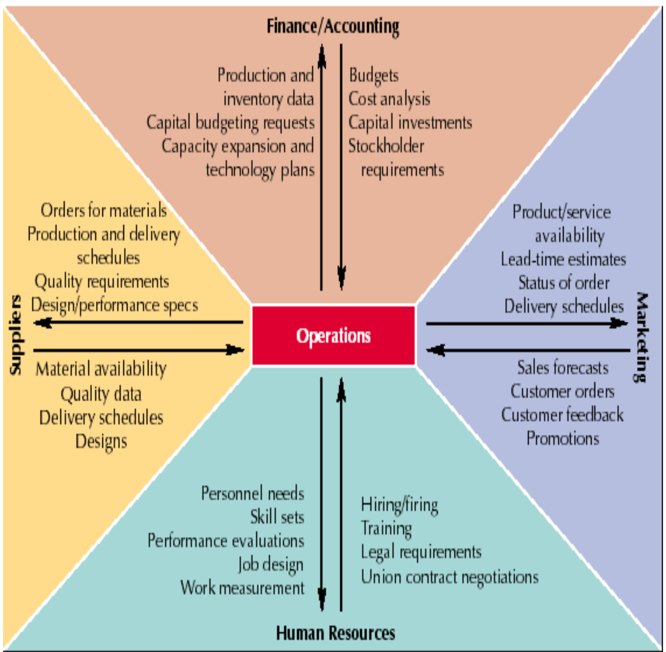
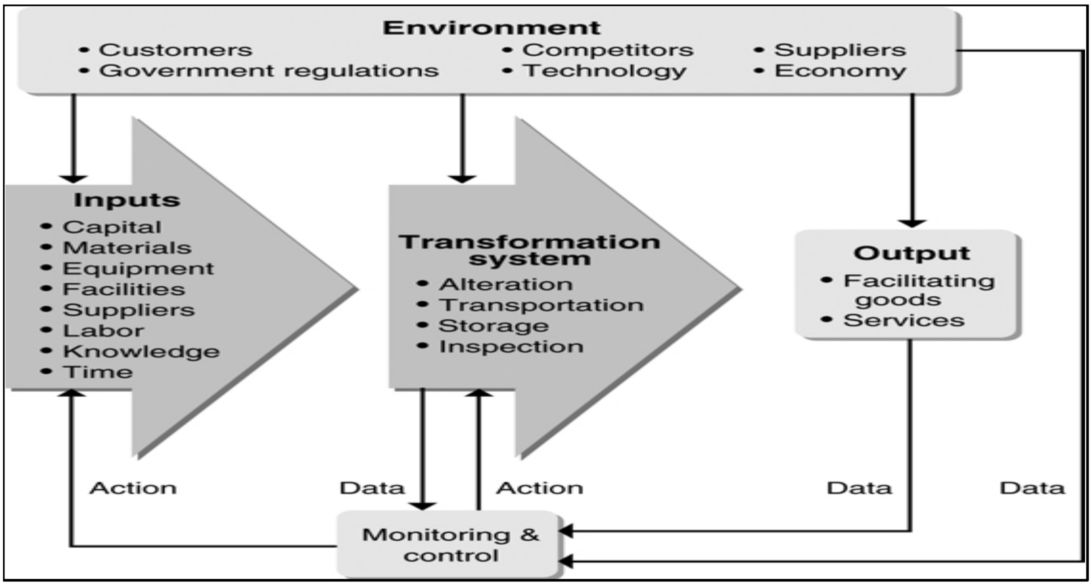


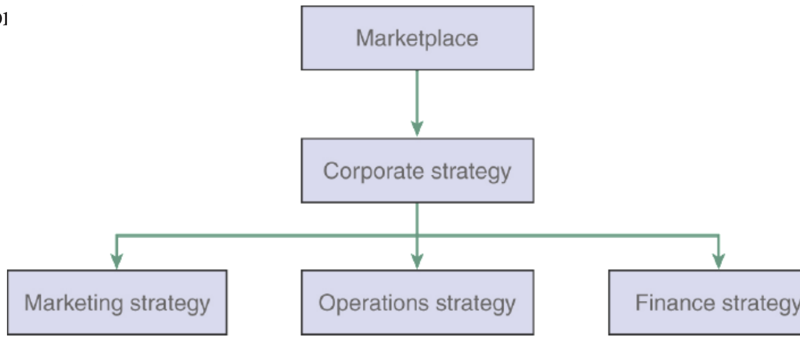
Figure 1.6. A production System model

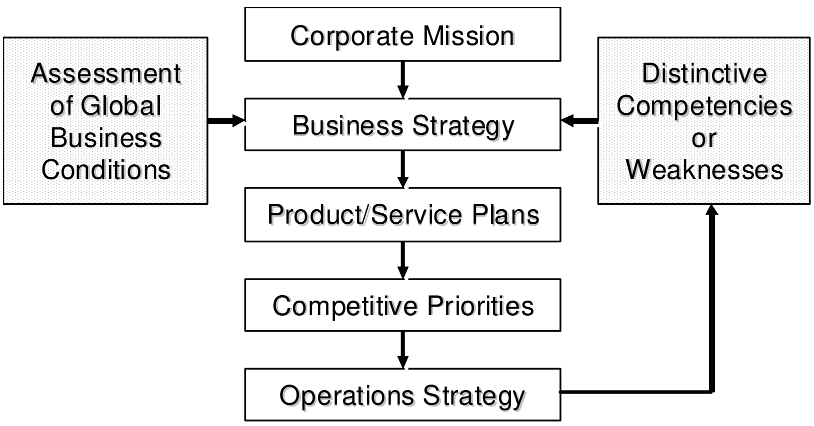


1.8. Operations Strategies

Management Decisions are classified into three types

- Strategic Decisions (long term)
- Tactical Decisions (medium-range)
- Operational Planning and Control (shor





A corporate mission is a set of long-range goals and including statements about:

the kind of business the company wants to be in

who its customers are

its basic beliefs about business

its goals of survival, growth, and profitability

Business strategy is a long-range game plan of an organization and provides a road map of how to achieve the corporate mission. Inputs to the business strategy are

Assessment of global business conditions - social, economic, political, technological, competitive

Distinctive competencies or weaknesses - workers, sales force, R&D, technology, management

Operations strategy is a long-range game plan for the production of a company's products/services, and provides a road map for the production function in helping to achieve the business strategy.

Low production costs - unit cost (labor, material, and overhead) for each product/service

Delivery performance - fast, on-time delivery

High quality products/services - customers' perception of degree of excellence of product/service

Customer service and flexibility - responsiveness to customer needs and ability to quickly change production/service volumes, configurations, etc.

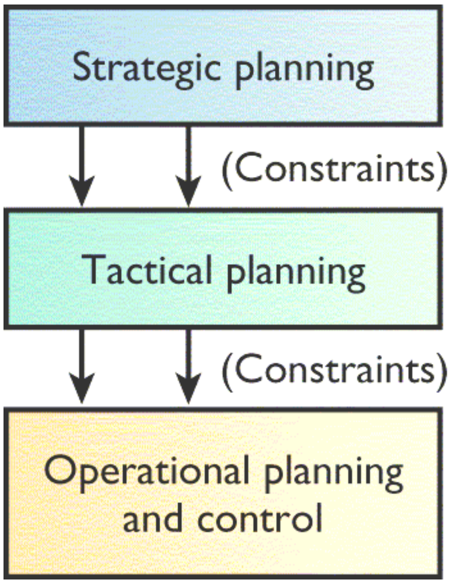
Key Elements in Operations Strategy include decisions about whether organization wants to be

- Innovator or imitator
- Product development and product life cycle decisions
- Product variety/ choices to be offered
- Outsourcing or vertical integration
- Location and logistics management
- Types of processes: whether continuous, batch or intermittent
- Adapted production technologies
- Price, quality, and delivery issues associated with production
- Small/large batch production decisions
- Workforce management including training and compensations

1.8.1 Operations Strategy Decisions

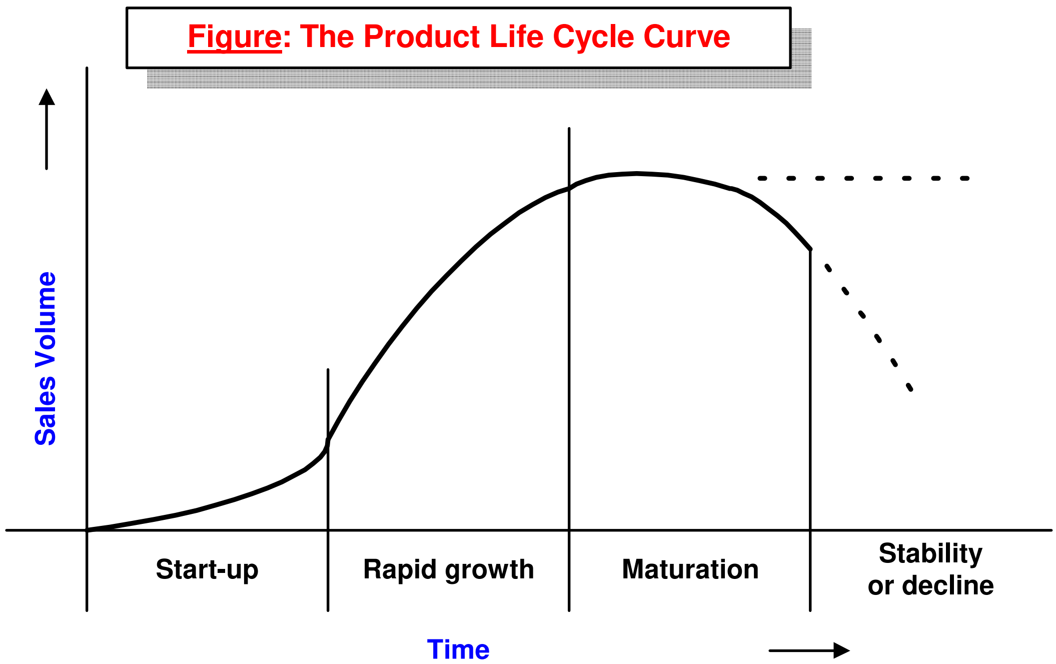
(a) Strategic (long-range); Needs of customers, (capacity planning). These decisions are of strategic importance and have long-term significance for the organization. Examples include deciding: the design for a new product's production process, where to locate a new factory, whether to launch a new-product development plan.

(b) Tactical (medium-range); Efficient scheduling of resources. These decisions are necessary if the ongoing production of goods and services is to satisfy market demands and provide profits. Examples include deciding: how much finished-goods inventory to carry, the amount of overtime to use next week, the details for purchasing raw material next month *(c) Operational planning and control (short-range);* Immediate tasks and activities. These decisions concern the day-to-day activities of workers, quality of products and services, production and overhead costs, and machine maintenance. Examples include deciding: labor cost standards for a new product, frequency of preventive maintenance, new quality control acceptance criteria



1.9 The Implications of Product and Process Life Cycles for Positioning Strategy

The characteristics of production systems tend to evolve as products move through their product life cycles. This linkage ensures that production takes on a proactive role and then can be used as a competitive weapon in the struggle to capture market share.



The product life cycle stages and related strategies include:

Start-up: Great variety, Low volume, Low competition, Compete on product characteristics

Growth: Increasing standardization, Increasing volume, Competition build up, Compete product quality and availability

Maturation: emergence of dominant design, high volume, few large competitors, compete on price and dependability

Stability or decline: high standardization, high volume and compete on price

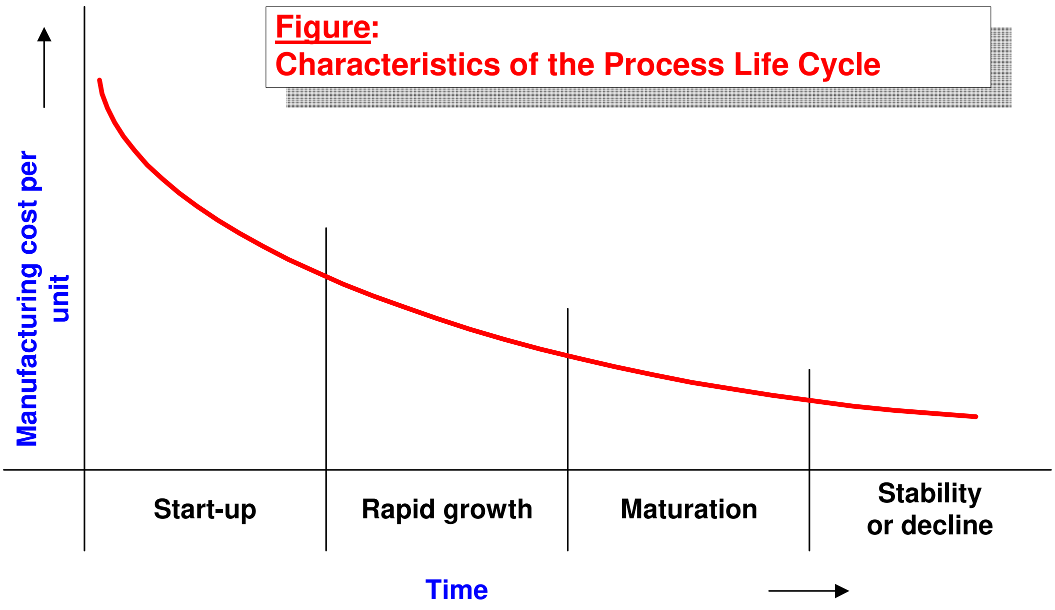


Figure: Characteristics of the Process Life Cycle

Process: Job shop Batch Flow Continuous Flow

1.10 Contributions of Operations management to the Society

Operations management has contributed tremendously to the society in many ways;

1. Higher Standard of Living
    a. Ability to increase productivity
    b. Lower cost of goods and services
2. Better Quality Goods and Services
    a. Competition increases quality
3. Concern for the Environment
    a. Recycling and concern for air and water quality
4. Improved Working Conditions
    a. Better job design and employee participation

1.11 SELF-ASSESSMENT QUESTIONS:

1. Explain the meaning of Operations Management.
2. Briefly explain Just-In-Time Production.
3. What are the Operations Strategy Decisions?

1.12 SUMMARY:

Operations Management is management of the conversion process which transforms inputs such as raw material and labor into outputs in the form of finished goods and services. Operations Management involves design, operation and improvement of productive systems. It is also defined as the management of an organization's productive resources of its productive system, which converts into the organization's products and services.Operations Management dates back to the industrial revolution. There was large number of developments in the post-civil war period, scientific management, human relations and behaviouralism, operations research, the service revolution and the computer/ internet revolution. Just-in-time is defined as "a philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity".

Operations management is important in various aspects such as marketing gets people to buy our product, finance makes sure we have the money to operate, accounting keeps track of what we spend, etc. The objectives of production and operations management are how to efficiently provide the customer with the right amount of products and services at the right time. Operations strategy decisions are classifies into three types i.e. strategic, tactical and operational planning and control decisions.Operations management has contributed tremendously to the society in many ways such as higher standard of living, better quality of goods and services, concern for the environment and improved working conditions.

1.13 GLOSSARY:

Just-In-Time (JIT): It is a methodology aimed primarily at reducing **times** within the **production** system as well as response **times** from suppliers and to customers.

Lead Time: It is the latency between the initiation and completion of a process. For example, the lead time between the placement of an order and delivery of new cars by a given manufacturer might be between 2 weeks and 6 months, depending on various particularities.

Outsourcing: It refers to shift tasks, operations, jobs, or processes to an external workforce, by contracting with a third party for a significant period of time.

Production System: It is a computer program typically used to provide some form of artificial intelligence, which consists primarily of a set of rules about behaviour but it also includes the mechanism necessary to follow those rules as the **system** responds to states of the world.

1.14 ANSWERS TO SELF-ASSESSMENT QUESTIONS:

1. Refer to section (1.2)
2. Refer to section (1.4)
3. Refer to section (1.6.1)

1.15 Terminal Questions

1. Define Operations Management and explain the need and scope of Operations Management in the decision making process.
2. What is Operations Management? Explain the nature and features of Operations Management.
3. Discuss the meaning and objectives of Operations Management. How it is to be used for Decision Making?
4. What is operation management's contribution to the society?
5. What are the most important factors affecting operations management today?
6. Discuss the historical events in operations management.

1.16. Suggested Readings

1. Chase, R. and Aquilano, N. (1995). Production and Operations Management. (7th Edition). Richard D. Irwin.
2. Dilworth, J.B. (1992). Operations Management: Design and Control for Manufacturing and Services. McGraw-Hill.
3. Meredith, J.R. (1992). The Management of Operations. (4th Edition). Wiley.
4. Pycraft, M. ; Singh, H. ; Phihlela, K. ; Slack, N. ; Chamers, S. ; Harland, C. ; Harrison, A. and Johnston, R. (1997). Operations Management. (1st Edition). Pitman Publishing.
5. Russel, R.S. and Taylor, B.W. III. (1995) Operations Management-Focusing on Quality and competitiveness. International Edition. (2nd Edition). Prentice-Hall.

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Chapter-2
Production System

Structure:

2.0 Learning Objectives:

After studying the lesson, you will be able to understand:

- Production systems
- Types of production systems
- Manufacturing process
- Types of manufacturing process
- Factors affecting the choice of manufacturing process
- Productivity Improvement

2.1. Introduction

Production is simply the conversion of inputs into outputs. It is an economic process that uses resources to create a commodity that is suitable for exchange. This can include manufacturing, storing, shipping, and packaging. Some economists define production broadly as all economic activity other than consumption. They see every commercial activity other than the final purchase as some form of production.

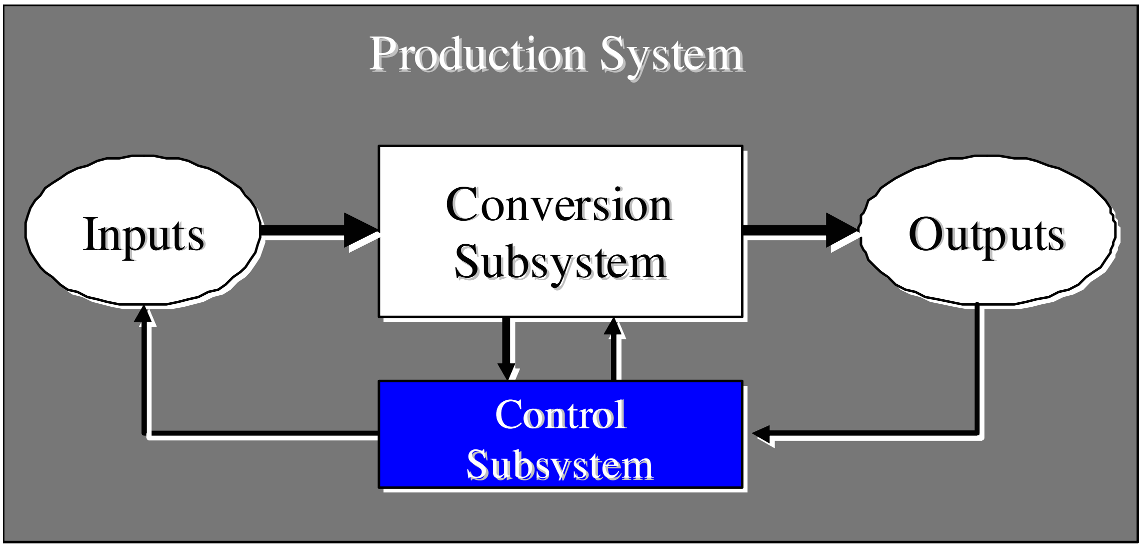
Production is a process, and as such it occurs through time and space. Because it is a flow concept, production is measured as a "rate of output per period of time". There are three aspects to production process:

1. the quantity of the commodity produced,
2. the form of the good produced,
3. the temporal and spatial distribution of the commodity produced.

A production process can be defined as any activity that increases the similarity between the pattern of demand for goods, and the quantity, form, and distribution of these goods available to the market place.

2.2 Meaning of Production System

Production system is a system whose function is to convert a set of inputs into a set of desired outputs. Production system can be depicted under with help of a diagram



The inputs or resources used in the production process are called factors by economists. The myriad of possible inputs are usually grouped into four categories. These factors are:

- Raw materials (natural capital)
- Labour services (human capital)
- Capital goods
- Land

Sometimes a fifth category is added, entrepreneurial and management skills, a subcategory of labour services. Capital goods are those goods that have previously undergone a production process. They are previously produced means of production. Some textbooks use "technology" as a factor of production.

In the "long run" all of these factors of production can be adjusted by management. The "short run" however, is defined as a period in which at least one of the factors of production is fixed. A fixed factor of production is one whose quantity cannot readily be changed. Examples include major pieces of equipment, suitable factory space, and key managerial personnel. A variable factor of production is one whose usage rate can be changed easily. Examples include electrical power consumption, transportation services, and most raw material inputs. In the short run, a firm's "scale of operations" determines the maximum number of outputs that can be produced. In the long run, there are no scale limitations.

The classical theory, further developed, remains useful to the present day as a basis of microeconomics. Some more means that deal with factors of production are as follows:

- **Entrepreneurs** are people who organize other productive resources to make goods and services. The economists regard entrepreneurs as a specialist form of labor input. The success and/or failure of a business often depends on the quality of entrepreneurship.
- **Capital** has many meanings including the finance raised to operate a business. Normally though, capital means investment in goods that can produce other goods in the future. It can also be referred to as machines, roads, factories, schools, and office buildings in which humans work in order to produce other goods and services. Investment is important if the economy is to achieve economic growth in the future.
- **Human Capital** is the quality of labor resources which can be improved through investments, education, and training.
- **Fixed Capital** this includes machinery, work plants, equipment, new technology, factories, buildings, and goods that are designed to increase the productive potential of the economy for future years.
- **Working Capital** this includes the stocks of finished and semi-finished goods that will be economically consumed in the near future or will be made into a finished consumer good in the near future. It includes also the liquid assets needed for immediate expenses linked to the production process (salaries, invoices, taxes, interests...).

2.3. Types of production systems

Product design is a strategic decision as the image and profit earning capacity of a firm depends largely on product design. Once the product to be produced is decided by the company the next step is to prepare its design. Product design consists of form and function. The form designing includes decisions regarding its shape, size, color and appearance of the product. The functional design involves the working conditions of the product. Once a product is designed, it prevails for a long time therefore various factors are to be considered before designing it. These factors are listed below: -

(a) Standardization

(b) Reliability

(c) Maintainability

(d) Servicing

(e) Reproducibility

(f) Sustainability

(g) Product simplification

(h) Quality Commensuration with cost

(i) Product value

(j) Consumer quality

(k) Needs and tastes of consumers.

Above all, the product design should be dictated by the market demand. It is an important decision and therefore the entrepreneur should pay due effort, time, energy and attention in order to get the best results.

Production system is the framework within which the production activities of an enterprise take place. Manufacturing process is the conversion process through which inputs are converted into outputs. An appropriate designing of production system ensures the coordination of various production operations. There is no single pattern of production system which is universally applicable to all types of production system varies from one enterprise to another.

Broadly there are three types of production systems which are mentioned here under: -

(a) Continuous production

(b) Job or unit production

(c) Intermittent production

In another classification there are three common types of basic production systems: the batch system, the continuous system, and the project system.

2.3.1 Continuous production:

It refers to the production of standardized products with a standard set of process and operation sequence in anticipation of demand. It is also known as mass flow production or assembly line production. This system ensures less work in process inventory and high product quality but involves large investment in machinery and equipment. The system is suitable in plants involving large volume and small variety of output e.g. oil refineries cement manufacturing etc. In the continuous system, items to be processed flow through a series of steps, or operations, that are common to most other products being processed. Since large volumes of throughput are expected, specially designed equipment and methods are often used so that lower production costs can be achieved. Frequently the tasks handled by workers are divided into relatively small segments that can be quickly mastered and efficiently performed. Examples include systems for assembling automobile engines and automobiles themselves, as well as other consumer products such as televisions, washing machines, and personal computers. Continuous production systems are often referred to as assembly systems or assembly line systems and, are common in mass production operations.

2.3.2. Job or Unit production:

It involves production as per customer's specification each batch or order consists of a small lot of identical products and is different from other batches. The system requires comparatively smaller investment in machines and equipment. It is flexible and can be adapted to changes in product design and order size without much inconvenience. This system is most suitable where heterogeneous products are produced against specific orders.

The two types of systems mentioned thus far are often found in combination. In the production of integrated circuits for electronic equipment, for example, thousands of circuits are processed as a batch on several large slices of silicon crystal through dozens, or even hundreds, of processing steps. The tiny circuits, each only a few millimetres on a side, are then separated and individually assembled with other circuit elements on a continuous line to produce the final product.

2.3.3 Intermittent Production:

Under this system the goods are produced partly for inventory and partly for customer's orders. E.g. components are made for inventory but they are combined differently for different customers. . Automobile plants, printing presses, electrical goods plant are examples of this type of manufacturing.

In the batch system, general-purpose equipment and methods are used to produce small quantities of output (goods or services) with specifications that vary greatly from one batch to the next. A given quantity of a product is moved as a batch through one or more steps, and the total volume emerges simultaneously at the end of the production cycle. Examples include systems for producing specialized machine tools or heavy-duty construction equipment, specialty chemicals, and processed food products, or, in the service sector, the system for processing claims in a large insurance company. Batch production systems are often referred to as job shops.

The third type of production system is the project, or "one-shot" system. For a single, one-of-a-kind product, for example, a building, a ship, or the prototype of a product such as an airplane or a large computer, resources are brought together only once. Because of the singular nature of project systems, special methods of management have been developed to contain the costs of production within reasonable levels.

2.4 Basic Manufacturing Processes

The nature of the process of production required by these three different types of production system are distinct and require different conditions for their working. Selection of manufacturing process is also a strategic decision as changes in the same are costly. Therefore the manufacturing process is selected at the stage of planning a business venture. It should meet the basic two objectives i.e. to meet the specification of the final product and to be cost effective.

Types of Manufacturing Process

The manufacturing process is classified into four types.

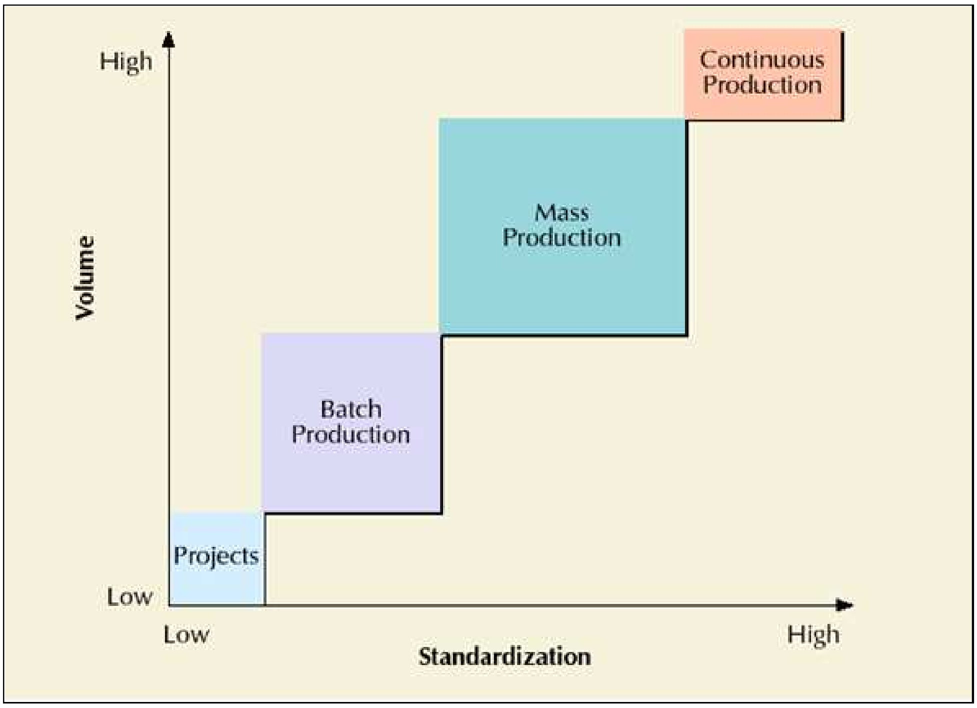
(i) Jobbing/ Project production

(ii) Batch production

(iii) Mass or flow production

(iv) Process/ Continuous Production

Figure 1.1. Types of manufacturing processes



(i) **Jobbing/ Project Production**: - Herein one or few units of the products are produced as per the requirement and specification of the customer. Production is to meet the delivery schedule and costs are fixed prior to the contract.

(ii) **Batch Production**: - In this, limited quantities of each of the different types of products are manufactured on same set of machines. Different products are produced separately one after the other.

(iii) **Mass or flow production**: Under this, the production run is conducted on a set of machines arranged according to the sequence of operations. A huge quantity of same product is manufactured at a time and is stocked for sale. Different product will require different manufacturing lines. Since one line can produce only one type of product, this process is also called as line flow.

(iv) **Process/ Continuous Production**: Under this, the production run is conducted for an indefinite period.

2.5. Factors Affecting the Choice of Manufacturing Process

Following factors need to be considered before making a choice of manufacturing process.

a) **Effect of volume/variety**: This is one of the major considerations in selection of manufacturing process. When the volume is low and variety is high, intermittent process is most suitable and with increase in volume and reduction in variety continuous process become suitable. The following figure indicates the choice of process as a function of repetitiveness. Degree of repetitiveness is determined by dividing volume of goods by variety.

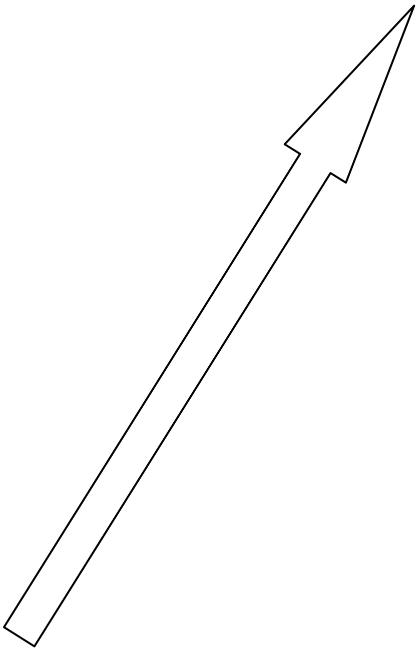


Figure1.2. Improved standardization with higher volume of production

b) **Capacity of the plant**: Projected sales volume is the key factor to make a choice between batch and line process. In case of line process, fixed costs are substantially highe The reverse is true for batch process thus at low volume it would be ch maintain a batch process and line process becomes economical at higher

c) **Lead time**: - The continuous process normally yields faster deliveries as process. Therefore lead-time and level of competition certainly influ production process.

d) **Flexibility and Efficiency**: - The manufacturing process needs to contemplated changes and volume of production should be larg

Hence it is very important for any organization to consider all above mentioned factors before taking a decision regarding the type of manufacturing process t

2.6 Productivity improvement.

As competitiveness becomes more important every da Low productivity in a company usually leads to that comp uncompetitiveness will lead directly to an increase i this firm more and take them longer to manufac competition. Productivity can be defined as the m input needed to produce the desired number of end items. The following formula can be used to express productivity:

$$\textbf{Productivity} = \frac{\textbf{Output}}{\textbf{Input}}$$

Outputs can be seen as the product/service produced or rendered. Inputs may vary from company to company. The most important inputs are labour, materials and energy. The outputs that is measured during the production process will to a large extend depend on the type of job performed. Examples of productivity measurements follow:

$$\textbf{M}^2 \textbf{ of bricks laid per day} = \frac{\textbf{M}^2 \textbf{ of bricks laid}}{\textbf{Hours worked}}$$

$$\textbf{Number of cars serviced in a day} = \frac{\textbf{Number of cars serviced}}{\textbf{Number of weeks}}$$

$$\textbf{Jobs done by a machine} = \frac{\textbf{Number of jobs}}{\textbf{Hours worked}}$$

The above formulae only measure a small part of the overall productivity. There are numerous other fractional ways to measure productivity. The main determinant as to which formula to use will depend upon what has to be measured. Thus, determining what is to be measured and the reason for measuring that specific entity will help in selecting the measuring unit. the objective that has to be obtained by that measurement is to be considered.

Example:

Given the information below,

1. 6 bricklayers laid 900 M^2 of bricks in one 8-hour shift.
2. The total production run for a machine in a 12 hour shift is 16 000 items. Out of the total production run only 12 650 items can be used.

Determining the productivity in each of the following cases will involve:

A. $$\text{Productivity} = \frac{M^2 \text{ of brick laid}}{\text{Hours worked}}$$

$$= \frac{900}{6x8}$$

$$= \frac{900}{48}$$

$= 19$ m^2 of brick laid per hour per bricklayer

2. $$\text{Productivity} = \frac{\text{Number of good items}}{\text{Production time}}$$

$$= \frac{12650}{12}$$

$= 1054$ items per hour worked

2.7 Techniques for Improvement of productivity.

Most companies do productivity analysis to determine what their real productivity performance is. Once that has been determined, their next objective is to improve on the current state of productivity. The productivity performance of a company will directly influence their competitiveness in comparison to their direct competitions. The lower their productivity is compared to their competitors, the less they will be able to compete. If they want to remain competitive the following steps can be taken:

- It is important that throughout the company for every operation a productivity measurement must be in place. Without such measurements in place it will be difficult to determine how well the company measures up to productivity standards. Management and control of the operations will become very difficult.
- Determine which of the operations are the most critical. Critical operations are those operations that will influence the whole process negatively. Bottleneck is a sure sign of critical operations. The determination of critical operations must be done for the whole process. If this is not done some critical operations may be overlooked with dire consequences to the company.
- Better methods must be employed that will enable a company to achieve better productivity results. Involve the employees when setting the productivity measures. Ask them to come forward with new ideas how productivity can be improved. This will make them feel involved and work harder to attain the set standards. Better methods can be put in place by using benchmarking. Study the methods the competition employs to achieve their high productivity. Employ the best methods in the company.
- Ensure that the objective that is set to better the productivity is obtainable and fair. There is nothing that demotivate people more easily than not reaching goals. This is counterproductive.
- Employees must see that management is part of this drive to attain a higher standard of productivity. Management must encourage and support in full the productivity program.
- The improvements must be measured and the results published on a regular basis. It is important for the moral of the employees to be informed how they are doing. If this is not done they will lose interest in the program. Then the program is doomed to failure.
- A clear distinction between productivity and efficiency must be spelled out. Efficiency is the maximisation of all available resources. Productivity is the maximisation and effective use of all the resources of a company.

To further enhance the productivity in a company there is certain factors that must be taken into account. In some instance management will be able to influence these factors but in other instances they will not be able to influence these factors. There are two main categories of factors that influence productivity. Firstly there is the outside or external factors that will influence productivity. These factors work in on the company from the outside and management can do nothing to change or influence them. Management has to work within the framework of these factors. One such an external factors could be labour legislation, Industrial policy of government, social and political factors etc. Management can only endeavour to minimise the impact that all the external factors will have on the productivity of the company. Secondly there are two sets of internal factors that will influence productivity. Management may experience difficulty in changing or influencing the second set of factors. Examples of such factors are the manner in which the company is organised, human resource policies and the work ethics of the employees. To attempt to change this set of factors, the essence of the company will have to be changed. Management will have to realise that they will have to manage productivity within this framework. The second set of factors that will influence productivity internally is within management's power to change and influence. For example, installing newer and better machines to enhance productivity. The result will be less breakdowns and better quality. Installing and continuously maintaining better processes and work methods can also improve productivity. Lastly management can help to achieve higher productivity by installing proper productivity measurement criteria.

Productivity has a far greater impact on a company than most people realise. The prosperity of a nation can be directly linked to the productivity of that nation. The lower the productivity is of that nation the fewer new job opportunities becomes available. A country where low productivity is rife becomes less competitive than their counterpart where productivity is high. The result is that the country with low productivity will price them out of the marketplace. The reason being that it will cost that country more to produce their products than it will cost the country with high productivity index. Employees should realise that when salary increases the productivity should increase roughly by the same percentage. In this instance the costs will keep on increasing but the output remain the same. The following example illustrates what will happen if productivity does not increase in direct proportion with salary increase.

Productivity measurement before increase.

A company produces 2000 items per day. Labour costs is R250, 00, cost of material is R100, 00 and the overheads is R170, 00.

$$\textbf{Productivity} = \frac{\textbf{Quantity produced}}{\textbf{Labour costs+material costs+overheads}}$$

$$= \frac{\mathbf{2000}}{\mathbf{250 + 100 + 170}}$$

$$= \frac{\mathbf{2000}}{\mathbf{520}}$$

$$= \textbf{3,8 rounded off 4}$$

4 items can be manufactured for every rand expended.

Productivity measurement after increase.

Assume that the labour costs have increase from R250,00 to R350, 00 and all the other figures remained the same.

$$\text{Productivity} = \frac{\text{Quantity produced}}{\text{Labour costs+material costs+overheads}}$$

$$= \frac{2000}{350 + 100 + 170}$$

$$= \frac{2000}{620}$$

$$= \text{3,2 rounded off 3}$$

In this case 3 items can be manufactured for every rupee spent. As a result of the productivity that did not increase, a decrease in the number of items produced resulted. Conversely it can be argued that it costs more to produce less. Wealth cannot and will not be created in this manner. For the creation of wealth and new job opportunities a high productivity index is required. It is therefore company's responsibility to ensure that the highest standard of productivity is maintained so that shareholders are adequately rewarded.

2.8 SELF-ASSESSMENT QUESTIONS:

1. Explain the meaning of Production System.
2. What are the different types of Production Systems?
3. Explain the factors affecting the choice of manufacturing process.

2.9 Summary

Companies face a challenge to manufacture products at economical prices. They need to embrace management principles surrounding production processes, which are effective for the products manufactured by them. An upfront planning and study of the critical factors of the manufacturing processes will not only help the organization to understand the steps they need to take in selecting the most appropriate manufacturing process but also help them identify areas of risk so that necessary control procedures are put in place. This will eventually help the company to eliminate the wastages and increase the production, productivity and profits.

2.10 GLOSSARY:

Human Capital: It refers to the the skills, knowledge, and experience possessed by an individual or population, viewed in terms of their value or cost to an organization or country.

Working Capital: It is the capital of a business which is used in its day-to-day trading operations, calculated as the current assets minus the current liabilities.

Intermittent: occurring at irregular intervals; not continuous or steady.

Productivity: It is defined as the efficient use of resources, labour, capital, land, materials, energy, information, in the production of various goods and services.

2.11 ANSWERS TO SELF-ASSESSMENT QUESTIONS:

1. Refer to section (2.2)
2. Refer to section (2.3)
3. Refer to section (2.5)

2.12. Terminal Assessment

1. Discuss with examples various manufacturing processes.
2. What factors affect the choice of manufacturing process? Elaborate.
3. What are your recommendations for improving the productivity?
4. Explain the concept of productivity with suitable illustrations.
5. Discuss the different means to improve productivity.

2.13. Suggested Reading

1. Steudel, H.J. and Desruelle, P. (1992). Manufacturing in the Nineties, Van Nostrand Reinhold, New York.
2. Stevenson, W.J. (1996). Production and Operations Management. (5th Edition) Irwin.
3. Ulrich, K.T. and Eppinger, S.D. (1995). Product Design and Development. McGraw-Hill.
4. Vollmann, T.E. ; Berry, W.L. ; Whybark, D.C. (1997). Manufacturing Planning and Control Systems. (4th Edition). Irwin/McGraw-Hill.
5. Chase, R. and Aquilano, N. (1995). Production and Operations Management. (7th Edition). Richard D. Irwin.
6. Dilworth, J.B. (1992). Operations Management: Design and Control for Manufacturing and Services. McGraw-Hill.
7. Adam, Everette E. Jr., and Ronald J. Ebert (2003). Production and Operations Management - Concepts Models and Behaviour. Pearson Education, New Delhi.
8. Buffa, E.S., Modern Production Management, New Delhi: Wily, 1988
9. Charantimath, Poornima (2003), Total Quality Management. Pearson Education, New Delhi.
10. Desai, Vasant Dr. (2004) Management of Small Scale Enterprises New Delhi: Himalaya Publishing House.

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Chapter-3
Inventory Management

Structure:

3.0 Learning Objectives:

After Studying the lesson, you will be able to know:

- What is inventory?
- Types of inventory
- Purpose of inventory mnagement
- Inventory Costs
- Inventory Systems
- Economic Order Quantity Models
- ABC classification
- Just in time
- Controlling Inventory

3.1. Introduction:

Inventory is stock of items kept to meet future demand for internal customers and external customers. Inventory system is the set of policies and controls that monitors levels of inventory and determine what level should be maintained, when stock should be replenished and how large the orders should be. Purpose of inventory management includes the decision about how many units to order and when to order.

There are two forms of demand i.e. dependent demand and independent demand. Dependent demand is demand for items used to produce final products, for example tyres stored at a Tyre manufacturing plant. Independent demand is demand for items used by external customers, for example, cars, appliances, computers, and houses are examples of independent demand inventory.

3.2. Types of Inventory

When dealing with the planning and control of inventories, it is important to distinguish between two types of demand. The demand types are dependent and independent demand. The dependent demand is that demand for the subassemblies or components that is used to manufacture the final product. This type of demand usually originates from within the company. It can be seen as an internal demand. The independent demand is the demand placed by a customer for the finished product manufactured by the company. This type of demand as a rule usually originates from outside the company. Therefore it stand to reason that each of these demand types will influence the demand for the product in a different manner. Ensuring that the production process runs smoothly the following types of inventories are held:

- **Finished goods inventory**. This is the final product of the company. It is kept in a warehouse awaiting a customer order. The products can also be in the warehouse waiting to be shipped to the customer after receipt of an order.
- Components or finished good that are **in transit** between the manufacturer and the customer. The items are not on the manufacturer's premises, since it have not yet been received by the customer. Because no payment and delivery has taken place it will show as stock held.
- Office supplies machine tools as well as the parts that are required to repair broken-down machines.
- **Raw materials** required for the manufacturing of goods as well as the purchased parts used in the manufacturing process.
- Half completed goods in the manufacturing process. This type of inventory is known as **work-in-process** (WIP).

Examples of the different types of inventory that can be held

BUSINESS/SERVICE	TYPE OF INVENTORY HELD
Doctor	Syringes, needles and dressings
Retailer	Goods for sale (Groceries)
Motor spares shop	All types of motor spares
Manufacturing	Raw materials, WIP, finished goods
Filling station	Fuel and lubricants
Fast food outlet	Ingredients for the food

From the above table it can be deduced why it is important to hold inventory in most of the cases. For example, if a customer walks into a fast food outlet ordering a burger a and the establishment does not have buns, cheese or the potatoes available to fill that order the customer will leave. This will result in a loss of sale and goodwill of the customer. No customer will support an establishment that can not satisfy his or her demand.

3.3. Purposes of Inventory

All firms keep a supply of inventory for the following reasons

- Smooth operation of the manufacturing process. In this type of inventory raw materials and work-in-process will be included. This type of inventory will ensure continuos production.
- Buffer stock. In this instance stock of half finished goods are kept at the machine to ensure that the machine will not be idle waiting for a job.
- For the prevention of stock-outs. Products are manufactured in excess of the existing demands. When a surge in the demand do occur, there will be enough stock in the warehouse to satisfy the unforeseen demands. This will lead to customer satisfaction.
- Seasonality. Firms whose demand is influenced by certain seasons use this type of inventory. During the off-season enough products are manufactured and stored to ensure that all the demands can be met during the high season. An example of this is a knitwear company that will produce enough jerseys during the summer, thus ensuring that enough garments will be available during winter.
- Order cycles. This will ensure the most advantageous buying of raw materials and other materials. Buying in cycles ensure that goods are purchased at the best economic order quantities. A result of this will be that the cost of reordering will be minimised.
- Take advantage of price discounts
- To provide a safeguard for variation in raw material delivery time.
- Inventory provides independence between stages and avoids work stop-pages
- Increase in prices. If there is a price increase in the pipeline, buy in larger quantities to offset or beat the imminent price increase. In this manner costs can be minimised.

Although inventories are indispensable to the efficient and effective operation of production systems but inventory is costly and large amounts are generally undesirable.

3.4. Inventory Costs

i. ***Carrying cost or Holding cost***; Includes cost of holding an item in inventory. Include costs for storage, facilities, handling, insurance, pilferage, breakage, obsolescence, depreciation, taxes and the opportunity cost of capital. Higher the inventory levels, higher the carrying costs. There are two basic ways of expressing holding costs. It can be expressed as a percentage of the selling price. E.g. holding cost per item is 10% of Rs. 5000. Thus the holding cost per item will be Rs. 500. Alternatively it can be expressed as a rupee value per item. E.g. holding cost per item is Rs. 150.

ii. ***Ordering cost***; Includes cost of replenishing inventory. These costs refer to managerial and clerical costs to prepare the purchase order. Costs will be incurred each time that inventory has to be replenished. The first part of the cost will be incurred when an order is placed. The second part of the costs will be incurred when the goods ordered are received into stock. The ordering costs are usually expressed as a fixed amount per order. E.g. Rs. 1,00,00 per order placed. The larger the lot sizes, the more inventories we hold, but we order fewer times during the year and annual ordering costs are less.

iii. ***Shortage cost***; Includes temporary or permanent loss of sales when demand cannot be met. When the stock of an item is depleted, an order for that item must be either wait until the stock is replenished or can be cancelled. There is a trade off between carrying stock to satisfy demand and the costs resulting from stockout. The costs that are included on a regular basis is loss of goodwill of the customer, charges for the late delivery of goods, loss of sale and a host of other subjective costs.

iv. ***Setup Cost***; the cost involved in changing over a machine to produce a different component or item is the setup cost. It includes labor and time to make changeover, cleaning, and new tools or fixtures. If there were no setup costs or loss of time for product changeover, many small lots would be produced. This would reduce inventory levels, with a resulting saving in cost.

3.5 Inventory Control Systems

An inventory system provides the organizational structure and the operating policies for maintaining and controlling goods to be stocked. The system is responsible for ordering and receipt of goods; timing the order placement and keeping track of what has been ordered, how much, and from whom. Mainly two types of system are followed for ordering the inventories; they are continuous systems and periodic systems.

i. ***Continuous system*** (fixed-order-quantity); In fixed order quantity systems a constant amount ordered *when* inventory declines to predetermined level. However, when the order is placed is allowed to vary. When inventory falls to a critical inventory level, the reorder point, triggers an order. Fixed order quantity model attempt to determine the specific point, R, the reorder level, at which an order will be placed and the size of that order, Q.

Assumptions of the Model

- Demand is known with certainty and is constant over time
- No shortages are allowed
- Price per unit of product is constant
- Lead time (time from ordering to receipt) for the receipt of orders is constant
- Order quantity is received all at once
- The setup cost is constant

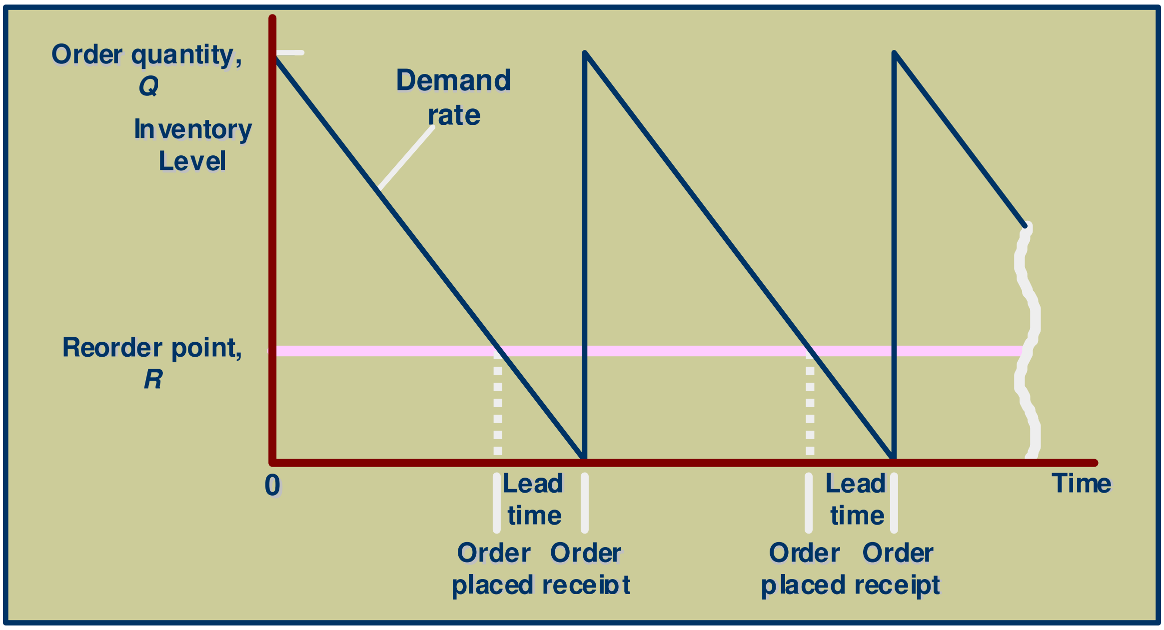


Figure 3.1 **Basic Fixed order quantity Model**

Total cost = Annual purchase cost + Annual ordering cost + Annual holding cost, which corresponds to:

$$TC = DC + \frac{D}{Q}O + \frac{Q}{2}H$$

- Q^* = optimal order quantity
- TC = Total annual cost
- D = Annual demand
- C = cost per unit
- R = Reorder point
- O = Ordering cost or cost of placing an order
- L = Lead time, in days
- H = Annual holding and storage cost per unit of average inventory (often holding cost is taken as a percentage of the cost of the item, such as $H=iC$, where I is the percentage carrying cost)

Taking the derivative of both sides of the equation and setting equal to zero, one obtains

$$\frac{dTC}{dQ} = 0 + \left(-\frac{DO}{Q^2}\right) + \frac{H}{2} = 0$$

$$Q^* = \sqrt{\frac{2DO}{H}}$$

The superscript asterisk (*) indicates the optimal order quantity or economic order quantity (EOQ).

Because this simple model assumes constant demand and lead time, no safety stock is necessary, and the reorder point, R is simply

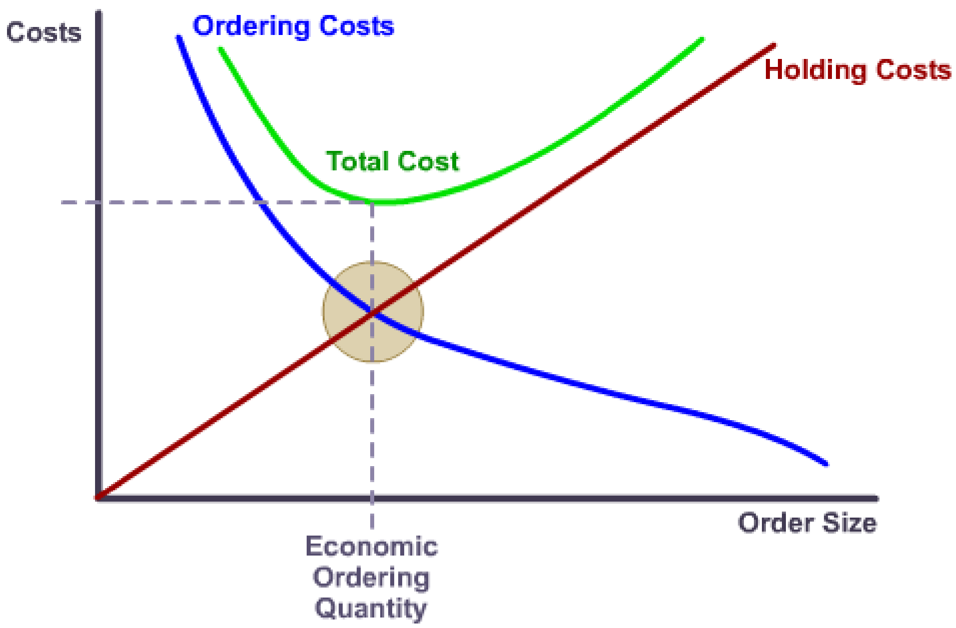
$$R = \bar{d}L$$

Where, $\bar{d}$ is average daily demand.

(a) Economic Order Quantity

The Economic Order Quantity (EOQ) is the number of units that a company should add to inventory with each order to minimize the total costs of inventory—such as holding costs, order costs, and shortage costs. The EOQ is used as part of a continuous review inventory system, in which the level of inventory is monitored at all times, and a fixed quantity is ordered each time the inventory level reaches a specific reorder point. The EOQ provides a model for calculating the appropriate reorder point and the optimal reorder quantity to ensure the instantaneous replenishment of inventory with no shortages. It can be a valuable tool for small business owners who need to make decisions about how much inventory to keep on hand, how many items to order each time, and how often to reorder to incur the lowest possible costs.

The EOQ model assumes that demand is constant, and that inventory is depleted at a fixed rate until it reaches zero. At that point, a specific number of items arrive to return the inventory to its beginning level. Since the model assumes instantaneous replenishment, there are no inventory shortages or associated costs. Therefore, the cost of inventory under the EOQ model involves a tradeoff between inventory holding costs (the cost of storage, as well as the cost of tying up capital in inventory rather than investing it or using it for other purposes) and order costs (any fees associated with placing orders, such as delivery charges). Ordering a large amount at one time will increase a small business's holding costs, while making more frequent orders of fewer items will reduce holding costs but increase order costs. The EOQ model finds the quantity that minimizes the sum of these costs.



(b) Safety Stock

Safety Stocks is the buffer added to on hand inventory during lead time. It can also be defined as the amount of inventory carried in addition to the expected demand. Safety stock can be determined based on many different criteria. A common approach is for a company to simply state that a certain number of weeks of supply be kept in safety stock.

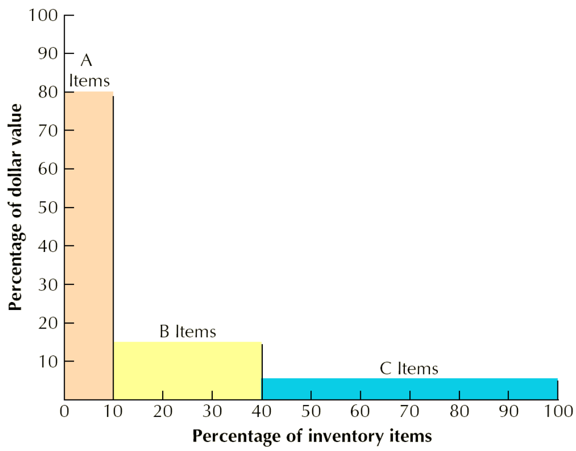
ii. ***Periodic system*** (fixed-time-period); order placed for variable amount after fixed passage of time. Counting inventory and placing orders periodically is desirable in situations such as when vendors make routine visits to customers and take orders for their complete line of products, or when buyers want to combine orders to save transportation costs.

Fixed time period models generate order quantities that vary from period to period, depending on the usage rates. These generally require a higher level of safety stock than a fixed order quantity system. The fixed order quantity system assumes continual tracking of inventory on hand, with an order immediately placed when the reorder point is reached. In contrast the fixed time period models assume that inventory is counted only at the time specified for review.

(a) ABC Classification

As a result of the high costs involved when holding stock, it becomes critically important to manage that stock properly. A general rule that can be used is that the higher the monetary value of an item, the higher the degree of attention given to that item. The lower the monetary value is the less attention is given to that item. This is only a general rule of thumb. Because of the high investment in inventory a more scientific method had to be found to do the analysis to determine how to manage inventory properly. The technique that came into being is popularly known as the **A-B-C classification system**. Other names used for this technique is the Pareto principle or the 80/20 principle. Inventory is classified into three main classes or categories. This is achieved by taking the monetary value of each item into account. Category A items contains all the high monetary value items. A small number of items, around 20%, are responsible for the largest slice of the costs. These items are usually responsible for 80% of the costs. That is why it is known as the 80/20 principle. 80% of the costs is caused by 20% of the items in stockholding. These items should be controlled strictly. Category B items is moderately important. The category C items are the least important. An item that is included in this category is usually of low monetary value. E.g. nuts, bolts and washers. They need the least attention.

Figure 3.3. ABC classification system



Management will concentrate their effort on controlling category A items. These types of items are usually of high value and can thus be sold outside the company at a profit. When discrepancies are found during stock taking it is usually in this category. Pilferage usually takes place of these items if employees see that control is lax.

- Class A; 5 – 15 % of units and 70 – 80 % of value
- Class B; 30 % of units and 15 % of value
- Class C; 50 – 60 % of units and 5 – 10 % of value

(b) Just-in-Time (JIT) Inventory Management.

A system that has the purpose to fulfill any demand placed on the system without delay. It will do so with the minimum of waste and only with high quality products. In simpler language it means to produce the product only when it is required. The required product will thus not be delivered earlier or later than the date specified by the customer. The following advantages can be derived from implementing a Just-in-Time system:

1. Costs will decrease.
2. Less defective products will be manufactured which will result in higher customer satisfaction. This is one of the reasons that costs will decrease.
3. Flexibility of the production system will increase.
4. New and more improved products can be made available to the consumers much faster.

Once a Just-in-Time system has been installed it should not be seen as the begin all and end all of the production system. The system must be managed properly and most importantly continuous improvements must be made to the system. Fine-tune the system continuously. The main purpose of a Just-in-Time system is to eliminate waste in the production process. Waste for this purpose can be defined as anything that does not add value to a product or service. Examples of waste is the following:

- An operator standing or sitting watching a machine while the manufacturing process is in progress. He being there does not add value to the product. The operator is there just in case the machine breaks down.
- The rework of sub standard quality products. No value is added when products have to be reworked because quality is low or non existent.
- The moving around of completed or half-completed products over long distances. No value is added as valuable time is wasted.
- Operators looking for lost or misplaced tools.
- Machines or work centers waiting for raw materials or parts to continue the manufacturing process. No value is added as both the machine and the operator is idle.
- Holding of inventory. The space is required for the holding of inventory could be put to better use.
- The breakdown of machinery. Better maintenance plans should be put into operation to eliminate this kind of waste.
- Continuous counting and recounting of existing stock. This is one of the biggest sources of waste in any business. Nothing constructive is produced. For this very reason no inventory exist in the Just-in-Time system.

- The overproduction of products. Many companies do this to prevent the non-availability of their products. This is one of the cases where "fat" is built in just in case of stock-outs.

It is therefore the goal of the Just-in-Time system to eliminate this waste and ensure a smooth production process. For a successful Just-in-Time system the following goals must be met:

- Waste must be eliminated. If waste is not eliminated resource that could have been used in production is kept busy with unproductive work.
- The system must be flexible. The system must be developed in such a manner that any mix of products can be handled without much of a problem. The balance and rate of throughput must be maintained at a steady rate.
- Prevent disruptions. Disruptions have a negative influence on the production process. It will interrupt the smooth flow of products through the production process. Once this happens one of the cornerstones of the Just-in-Time system is absent. Factors such as poor quality, continuous changes in the production schedule, the late receipt of materials and the breakdown of machines will cause disruptions to the smooth flow of products through the production process.
- Delivery times of raw materials and the set-up times of machines must be reduced. The longer these times are, the less value is added to the final product. This will also impact negatively on the flexibility of the production process.
- Keep the minimum inventory. Ideally, there should be no inventory in a Just-in-Time system. The more inventory that is held, the more space is required. This will push up the cost of the final product.
- Good supplier network. To eliminate the holding of stock a reliable supplier network must be build up. The smaller the number of suppliers the more reliable the deliveries become. The suppliers must constantly be kept informed of when and what quantities of goods are required. It will be a great help if the suppliers are situated close to the factory.
- Source quality. Quality is a prerequisite for a successful Just-in-Time system. Ensure that only high quality parts and raw materials are received from the suppliers. In this manner the manufacturing of zero defect products become more viable.

Many benefits can be derived from a properly installed Just-in-Time system. The following is the main benefits of Just-in-Time:

- All levels of inventory (work-in-process, bought in goods and finished goods) will be reduced. If properly installed Just-in-Time will trim inventory down to only the materials needed for that day's production.
- Quality of the goods produced will improve. Rework and scrap will be reduced and eventually eliminated.
- All the costs involved will be reduced. This include the cost of rework, scrap, inventory holding costs as well as the cost of constantly setting up the machines.
- The time taken to manufacture a finished product will be reduced.
- The productivity of both the man and the machine will improve because of better utilization.
- There will be more flexibility in the production process.

- Better relationships with the suppliers will be the result of a successful implementation of a Just-in-Time system.
- The scheduling and controlling of jobs will be simplified.
- Due to fewer interruptions in the manufacturing process capacity will be increased. This will come to pass because of better quality, better training of employees and less machine breakdowns.
- Use employees more productive. Employees can now become actively involved in the solving of production problems. The people working in the process is usually more aware where problems is likely to occur and how to solve them. Listen to their input.
- Indirect labour (progress chasers, storemen and planners) can be reduced.
- More types of products can be produced.

To become more competitive and stay competitive, more and more companies are considering conversion to a Just-in-Time system. Those that choose not to convert, risk becoming irrelevant in the manufacturing environment. Their cost will be high, capital will be tied up in unproductive stock holing and their quality will be almost non existent. It is for these reasons that the Japanese and other Asian countries dominated the world markets in the late 1970's through the 1980's and early 1990's. It is only lately that the Western countries have started competing on an equal footing with the Asian countries. These countries have learned their lessons well. If Indian firms want to compete in the global market they to will have to learn these lessons. If they do not, India will always remain a manufacturing backwater.

3.6. Controlling Inventory

Controlling inventory does not have to be an onerous or complex proposition. It is a process and thoughtful inventory management. There are no hard and fast rules to abide by, but there are some extremely useful guidelines. A five step process can help any business bring this potential problem under control to think systematically thorough the process and allow the business to make the most efficient use possible of the resources represented. The final decisions, of course, must be the result of good judgment, and not the product of a mechanical set of formulas.

3.6.1 Process of Controlling Inventory

STEP 1: Inventory Planning

Inventory control requires inventory planning. Inventory refers to more than the goods on hand in the retail operation, service business, or manufacturing facility. It also represents goods that must be in transit for arrival after the goods in the store or plant are sold or used. An ideal inventory control system would arrange for the arrival of new goods at the same moment the last item has been sold or used. The economic order quantity, or base orders, depends upon the amount of cash (or credit) available to invest in inventories, the number of units that qualify for a quantity discount from the manufacturer, and the amount of time goods spend in shipment.

STEP 2: Establish order cycles

If demand can be predicted for the product or if demand can be measured on a regular basis, regular ordering quantities can be setup that take into consideration the most economic relationships among the costs of preparing an order, the aggregate shipping costs, and the economic order cost.

When demand is regular, it is possible to program regular ordering levels so that stock-outs will be avoided and costs will be minimized. If it is known that every so many weeks or months a certain quantity of goods will be sold at a steady pace, then replacements should be scheduled to arrive with equal regularity. Time should be spent developing a system tailored to the needs of each business. It is useful to focus on items whose costs justify such control, recognizing that in some cases control efforts may cost more the items worth. At the same time, it is also necessary to include low return items that are critical to the overall sales effort.

If the business experiences seasonal cycles, it is important to recognize the demands that will be placed on suppliers as well as other sellers.

A given firm must recognize that if it begins to run out of product in the middle of a busy season, other sellers are also beginning to run out and are looking for more goods. The problem is compounded in that the producer may have already switched over to next season's production and so is not interested in (or probably even capable of) filling any further orders for the current selling season. Production resources are likely to already be allocated to filling orders for the next selling season. Changes in this momentum would be extremely costly for both the supplier and the customer.

On the other hand, because suppliers have problems with inventory control, just as sellers do, they may be interested in making deals to induce customers to purchase inventories off-season, usually at substantial savings. They want to shift the carrying costs of purchase and storage from the seller to the buyer. Thus, there are seasonal implications to inventory control as well, both positive and negative. The point is that these seasonable implications must be built into the planning process in order to support an effective inventory management system.

STEP 3: Balance Inventory Levels

Efficient or inefficient management of merchandise inventory by a firm is a major factor between healthy profits and operating at a loss. There are both market-related and budget-related issues that must be dealt with in terms of coming up with an ideal inventory balance:

- Is the inventory correct for the market being served?
- Does the inventory have the proper turnover?
- What is the ideal inventory for a typical retailer or wholesaler in this business?

The ideal inventory is the inventory that does not lose profitable sales and can still justify the investment in each part of its whole.

An inventory that is not compatible with the firm's market will lose profitable sales. Customers who cannot find the items they desire in one store or from one supplier are forced to go to a competitor. Customer will be especially irritated if the item out of stock is one they would normally expect to find from such a supplier. Repeated experiences of this type will motivate customers to become regular customers of competitors.

STEP 4: Review Stocks

Items sitting on the shelf as obsolete inventory are simply dead capital. Keeping inventory up to date and devoid of obsolete merchandise is another critical aspect of good inventory control. This is particularly important with style merchandise, but it is important with any merchandise that is turning at a lower rate than the average stock turns for that particular business. One of the important principles newer sellers frequently find difficult is the need to mark down merchandise that is not moving well.