Operations Management

DMGT501

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LOVELY PROFESSIONAL UNIVERSITY

OPERATIONS MANAGEMENT

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SYLLABUS

Operations Management

Objectives: The course is designed to acquaint the students with decision making in Planning, scheduling and Control of production and operations Management functions in both manufacturing and services; impact of Information Technology and technological advancement for up gradation of facilities and Productivity Improvement in operations.

S. No.	Topics
1.	***Operations Management:*** Definition, production functions, Functions & Responsibilities of Production management and its relations to other management functions, Automation . Difference between services and Manufacturing. Competitiveness Strategy and productivity. Computing productivity
2.	***Product and Service Design:*** Objectives, legal and Environmental issues, Lifecycles, Standardization, Mass customization Delayed Differentiation. Modular design, Reliability, Improving reliability. Phases in product design and development. Design for manufacturing, concurrent Engineering, CAD, and Recycling Component Commonality. Service Design , Difference between product design and service design
3	***Capacity Planning:*** Defining & measuring capacity, determinants of effective capacity. Determining capacity requirements, calculating processing requirements, make or buy decisions. Developing capacity alternatives. Challenges of planning service capacity. CVP Analysis
4	***Process Selection and Facility Layout:*** Types of manufacturing Processes. Flexible manufacturing Systems, CIM. Facilities layout, repetitive product and process layouts. Fixed position layout, combination layout, Cellular layout, Group technology, other service layouts, designing product layouts. Assembly line balancing. Closeness Rating
5	***Facility Location:*** Need for location decisions, Nature of location decisions, Factors affecting location & site decisions, selection of the site for the plant. Procedures for location decisions. Factor rating method. Centre of gravity Method. Least cost method
6	***Quality Assurance and Control:*** Inspection, Statistical process control, Control charts, acceptance sampling concept, risks, cost of quality control; ISO Quality Systems: ISO:9000, ISO:14000, Total Quality Control - concept, KAIZEN, six sigma concept
7	***Inventory Management and Control:*** Nature and importance of Inventory , Functions and Objectives , Requirements for effective Inventory Management , Inventory costs, Inventory Classification System , ABC Analysis , EOQ Models , Economic Production Quantity Model
8	***Supply Chain Management:*** Need for Supply Chain Management, Benefits, Elements of SCM , Logistics , EDI , E-commerce . Requirements for SCM , Steps and Optimization
9	***Purchasing:*** Purchasing Interfaces, Purchasing cycle, Value Analysis, centralized vs Decentralized Purchasing. Ethics in Purchasing
10	***JIT :*** JIT and lean Operations , JIT in Services

CONTENT

Unit 1: Introduction to Operations Management

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Objectives

After studying this unit, you will be able to:

- Discuss production functions
- State functions and responsibilities of production management
- Explain the relations of production management with other management functions
- Define automation

Notes

- State differences between services and manufacturing
- Explain competitiveness and productivity
- Discuss computing productivity

Introduction

Man started engaging in the activity of production soon after its existence. Agriculture was the first production activity. Since then the range of production and manufacturing activities has expanded in terms of capacity and efficiency. Today, machines have replaced men in basic production activities. Men only supervise machines and are supervised by them as well. Thus, production is a much more complex function. Also, it is one of the most critical functions of modern management.

1.1 Definition

Operations Management is the management of an organisation's productive resources or its production system, which converts inputs into the organisation's products and services.

There are basically three schools of thought:

1. Classical
2. Behavioural
3. Modelling

Classical Management

Classical management emphasizes:

1. Economic efficiency as the overall production effectiveness of the organisation: Scientific management.
2. Management as a continuous process of planning, organising and controlling: Process management.

Behavioural Management

Behavioural management emphasises:

1. ***Human Relationship:*** Behavioural scientists recognise that people are complete and have multiple needs and that the subordinate-supervisor relationship directly affects productivity.
2. ***Behavioural Science:*** The science which explored how human behaviour is affected by leadership, motivation, communication, interpersonnel relationships and attitude change.

Modelling as Management

Modelling as management emphasises:

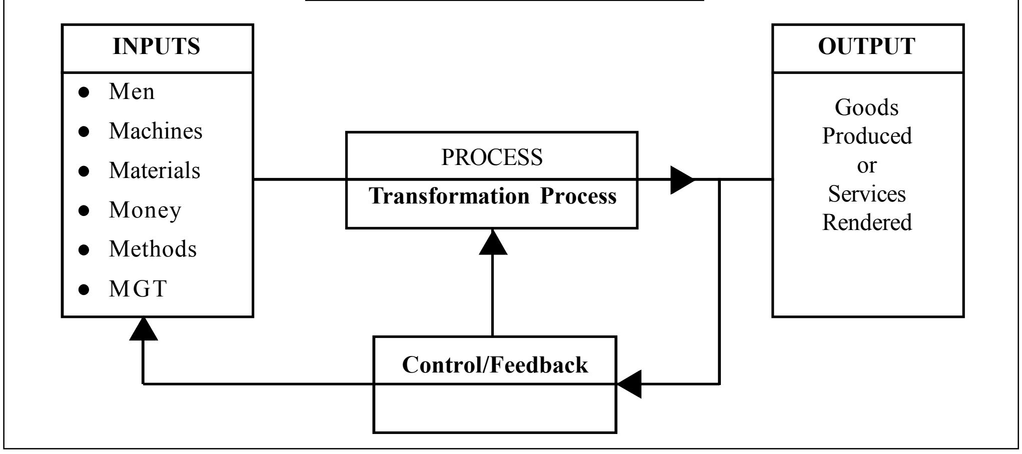
1. Decision-making
2. System Management
3. Mathematical Modelling

1.2 Production Functions

Production may be defined as the conversion of inputs – men, machines, materials, money, methods and management (6 Ms) into output through a transformation process. Output may be goods produced or services rendered.

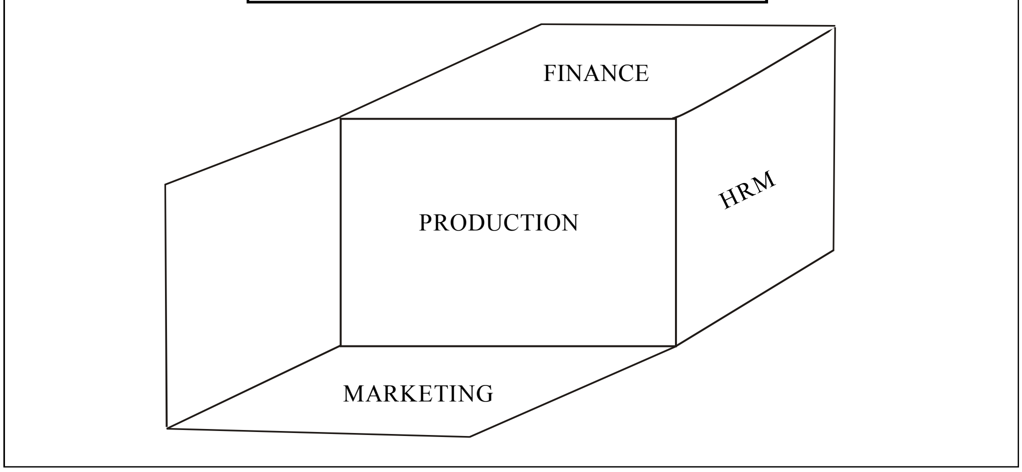
"Goods produced" is for the manufacturing concerns and "services rendered" is for the service operation units such as banks, hospitals, hotels/restaurants, etc. In this sense, production management may be viewed as operations management.

Figure 1.1: Production as a System



Production is a primary business function along with marketing and finance, other management areas being HRD (Personnel & Industrial Relations) and Materials Management, etc. Marketing establishes the demand for goods and services, finance provides the capital and equipment while production actually makes the goods or services. In this sense, it plays a vital role in achieving a firm's strategic plans or goals.

Figure 1.2: Production as Coordination Function



Further, as the production function produces the goods and services, it typically involves the greatest bulk of the companies' employees and is responsible for a large portion of the firm's assets.

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Moreover, production has a major impact on the quality of the goods and cost of production. In this respect, production is a visible face of the company and is thus the central function of an organisation and hence, we may call production as the heart of any organisation.

1.3 Functions and Responsibilities of Production Management

Production management is viewed as a continuous process of planning, organising and controlling:

1. ***Planning:*** It includes all activities that establish a course of action. These activities guide future decision-making. It involves product planning, facility planning and designing of the conversion process.
2. ***Organising:*** It includes all activities that establish a structure of tasks (organisation structure) and authority. Thus, it determines the activities required to achieve the operations, sub-systems goals and assign authority and responsibility for carrying them out.
3. ***Controlling:*** It includes all activities that ensure that actual performance is in accordance with planned performance. This is done by developing standards and communication networks necessary to ensure that the organising, staffing and directing functions are pursuing appropriate plans and achieving objectives.

The major objective of production management is to produce quality goods and services. In present day position, the objective of any firm is to increase profitability through higher efficiency, higher productivity, by improving quality, and to give customer more confidence by providing him products of quality at the right price and at the right time (JIT concept).

This can be achieved through:

1. Optimal use of resources (men, machines and materials).
2. By maximising use of manpower and machines, or minimising wastage of materials.
3. Ensuring quality of goods at minimal cost through use of statistical quality control techniques.
4. Contributing towards all round productivity through decision-making and quantitative techniques or techniques.

1.3.1 Scope of Production Management

Scope of production management includes:

1. Activities relating to designing or formulation of the production system.
2. Activities relating to analysing and controlling of production operation after the production system has been activated.

1.3.2 Activities relating to Production System Designing

These activities concern the production engineering which includes problems relating to:

1. Design of tools and drawings;
2. Designing development and installation of equipments;
3. The selection and operation of the size of the firm;

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4. The selection of the overall plans;
5. Location plans;
6. Plant layouts;
7. Materials handling systems, etc.

Besides, the human factor problems and research and development are also considered.

1.3.3 Activities relating to Analysis and Control of Production

The major ones are:

1. ***Production Planning:*** It includes preparation of short term production schedules, plan for maintaining the records of raw material and finished and semi-finished stock; specifying how the production resources of the concern are to be employed over some future time in response to the predicted demand for products and services.
2. ***Production Control:*** After planning, the next managerial production function is to control the production plans because the production plans cannot be activated unless they are properly guided and controlled. For this purpose, production manager has to regulate work assignment, service work progress and check and remove discrepancies, if any, in the actual and planned performances. A production manager has to look after the production control activity through:
   (a) Control on inventory such as raw materials, purchased parts, finished goods etc.
   (b) Control on work in progress through production control.
   (c) Control of quality through process control.

1.4 Relating Production Management with other Management Functions

Well-designed manufacturing and service production exploit a company's distinctive competencies – the strengths unique to that company – to meet these needs. Such strengths might be a particularly skilled or creative workforce, strong distribution networks, or the ability to rapidly develop new products or quickly change production-output rates. A good production manager will interface with other functions in order to exploit the competencies of the organization.

We can analyze the interface requirements from another angle also – from the point of view of Production Management's processes. Generally, processes involve combinations of people, machines, tools, techniques, and materials in a systematic series of steps or actions.

The overall value chain extends from suppliers to customers. Inputs consist of the sources related to materials like capital, equipment, personnel, information, and energy used to produce the desired outputs. Inputs typically are selected by the production function in association with other functions. Outputs are the final product whether of tangible goods or intangible services.

Some of the interfaces with other functional areas in the organization are described below:

1. ***Production Management – Marketing Interface:*** Marketing is responsible for understanding customer needs, generating and maintaining demand for the firm's products, ensuring customer satisfaction, and developing new markets and product potential. The firm's strategic positioning and its market segmentation decisions to a large extent determine the manufacturing and production strategy.

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In addition, marketing is the key information gatekeeper between production and the product markets. Marketing determines the kind of product customer's value. This starts prior to product development, positioning, pricing, forecasting and promotions both before and after product launch. Interdisciplinary co-operation involving production and marketing decisions go back over many decades.

Conflicts between production and marketing in most organizations result from the lack of broad agreement on critical organizational decisions such as the width of the product line, the amount of time taken to deliver the product, and service or quality levels. The interface between these two functions offers wide leverage in most organizations – increased understanding and trust between production and marketing propels many organizations to higher levels of effectiveness.

2. ***Production Management – Finance Interface:*** Capital equipment, cost-control policies, price-volume decisions and inventories constitute the interface with financial decision-making. As acquisition and management of assets is an important part of decision making, finance and production need to work together to understand the nature of technology used in production and the practice-performance gap in their organization.

   Tracking performance requires that the organization develops common, objective platforms for performance evaluation. Finance provides data on product and service costs that help managers evaluate operational performance. Production managers should have knowledge of financial procedures, limits, and capabilities. The effectiveness of operational planning and budgeting is often driven by the level of co-operation between these two areas.

3. ***Production Management – Design Interface:*** Shrinking product lifecycles have been adding to the demands on the product development process. This is especially true for industries that have a high clock-speed. Launching more new products faster requires tight integration between the design and Production Management functions. Initiatives such as simultaneous engineering and early supplier involvement in the product design process not only add to the role of production but also improve the perception of value provided in the product and service concept design process.

   In addition, process development and engineering is responsible for production methods necessary to make the products. This function has a great impact on production.

   Therefore, co-operation between these three functions, i.e., process engineering, design and production, leads to improved organizational performance.

4. ***Production Management – Human Resource Interface:*** No plant manager anywhere would ignore the role of good people management in running an efficient operation. The human resource function includes operation's approaches such as continuous improvement and total quality that rely mainly on human inputs. Decisions about people and the organization of the production function interact significantly with both structural and infrastructural decisions. Such issues are not unique to the production function, however; they impact other functions and are dealt with more effectively through the human resource management function.

   In services, the human resource focus is vital, as customer's perceptions of an organization are generally formed by their interaction with customer contact personnel, such as customer service representatives. As organizations increasingly opt for 'flextime', the production function has to develop unique process configurations to accommodate employees with minimum disruption in the flow of work. Production Management and Human Resource departments have to co-operate for recruiting and training employees,

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enhancing employee well-being and development, and fostering motivation that are vital to the success of management policies in practice.

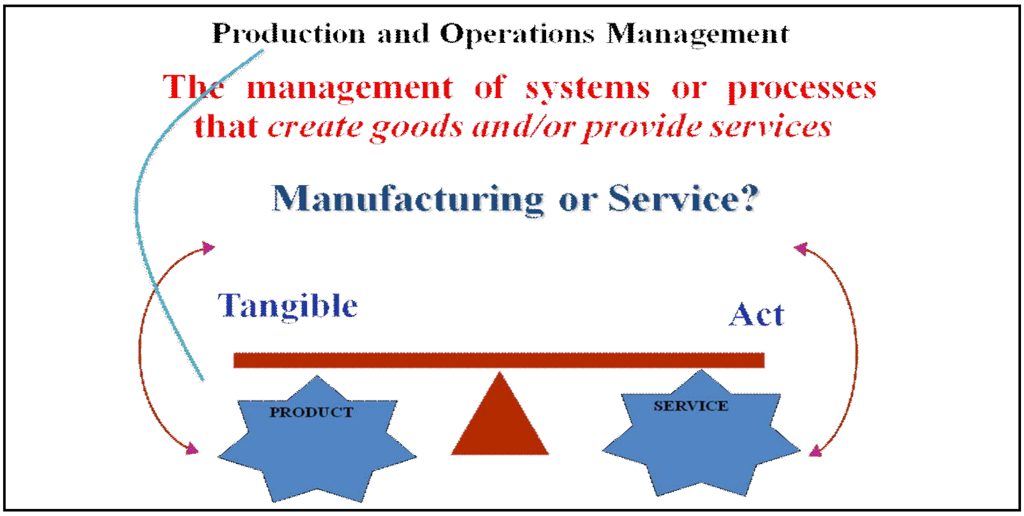
5. ***Production Management – Information Systems:*** Information systems provide, analyze, and co-ordinate the information needs of production. The distributed processing environment and the growth and evolution of Enterprise Resource Planning (ERP) systems for the organization have a direct impact on production. It allows organizations to generate relevant information and make appropriate information available when needed. The operational plans become the driver of all business planning including recruiting, cash flows, and marketing promotions. With Computer Integrated Manufacturing (CIM) systems IT plays a very important role.

In many organizations, similar activities are performed at different locations or at the same location by different people. Examples would be a manufacturer with plants spread out all over the world. However, knowledge is rarely, if ever, shared among employees performing similar jobs. Information technology provides an option for managing and sharing knowledge. It dramatically improves the task of managing knowledge. Advances in process automation allow firms to redefine their core processes and design better systems to accommodate the needs of product and service variety. E-commerce creates new demands for managing processes while also providing new opportunities for reconfiguring them. Much progress in information technologies is wasted if the production function does not respond to the challenges created by the increased availability of information and knowledge.

This approach emphasizes cross-functional thinking and relates it to the context of overall activities of the organization. Production Management measures the effectiveness of people, processes, and technology so that an enterprise can perform better, faster, and with greater productivity. It provides customers with products and services; and supports corporate strategies by working with marketing, finance and human resource areas.

Differences between Production and Operation Management

The field of management that deals with the supervision, planning and redesigning business operations in the manufacture of services as well as goods is called as Operations Management. This comprises the responsibility of making certain that the operations in a business are carried out in an efficient as well as effective manner for both parties. The organizational lifecycle operation inside a firm that deals with the forecasting, planning or marketing of products or a particular product at all stages of the life cycle of that product is called as Product management.



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Both Operations Management and Production Management have a big impact on our industries. While Operations Management is about the administration and planning of the business operations in the production as well as the service of goods, Product Management is the organizational life cycle procedure inside a company that is concerned with the prediction, planning and marketing goods at all phases of the life cycle of that particular product or products.

Production is the part of a business venture that produces, builds or manufactures a product for use and distribution. Management if the area of a business that deals with clerical issues, generally including hiring, payroll, acquiring necessary raw materials, bill paying and other related "office" duties.

Production management is the planning, organisation, staffing, leading, control and coordinating of human and material resources for excution of the facility in a specific function to meet pre-determined objectives in the constraints of time cost and quality. Tasks and a completion date. This is further explained as the management of a specific project. A Project Manager would typically oversee the delivering of projects on time, assigning tasks to developers and designers and ensuring client satisfaction.

Operations Management refers to the ongoing management of daily works of a company, such as technical support, network management, etc. With Operations Management, there is no set end point. An Operations Manager would typically be involved in all operations of a company, ensuring that everything is running smoothly and that staffs are delivering correctly. Let's look at an example - A web agency may have many projects running at the same time and once these projects are deployed, the project is finished, in terms of operations management, the operations manager is still occupied with the day to day support and management of the deployed project, ensuring that it is still running correctly, fixing various problems and so forth.

1.5 Automation

Automation is the self-controlling operation of machinery that reduces or dispenses with human communication or control when used in normal conditions.

Did u know? Automation was first introduced in the late 1940s by the Ford Motor Company.

In other words, it is the act or process of converting the controlling of a machine or device to a more automatic system, such as computer or electronic controls.

Automation plays an increasingly important role in the global economy and in daily experience. It increases the operational efficiency of the organisations. Engineers strive to combine automated devices with mathematical and organizational tools to create complex systems for a rapidly expanding range of applications and human activities.

1.5.1 Advantages of Automation

1. Replacing human operators in tedious tasks.
2. Replacing humans in tasks that should be done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, under the water, etc.)
3. Making tasks that are beyond the human capabilities such as handling too heavy loads, too large objects, too hot or too cold substances or the requirement to make things too fast or too slow.

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4. Economy improvement. Sometimes and some kinds of automation implies improves in economy of enterprises, society or most of humankind.

1.5.2 Disadvantages of Automation

1. It faces technology limits. Technology is not able to automate all the desired tasks.
2. The cost of automation is difficult to predict. The research and development cost of automating a process is difficult to predict accurately beforehand. Since this cost can have a large impact on profitability, it's possible to finish automating a process only to discover that there's no economic advantage in doing so.
3. The initial costs involved are relatively high. The automation of a new product required a huge initial investment in comparison with the unit cost of the product, although the cost of automation is spread in many product batches. The automation of a plant required a great initial investment too, although this cost is spread in the products to be produced.

Caselet

Toyota Kirloskar Looking at Higher Level of Automation

– by K Giriprakash

Toyota-Kirloskar may increase the automation in its second plant because of its higher capacity and hence may need fewer workers to run the operations.

The existing plant at Bidadi, 40 km from Bangalore, has the capacity to manufacture 60,000 vehicles and is one of the least automated plants of the world's largest car maker, Toyota Motor Corporation. The new plant, which will also come up near the existing plant, will manufacture the mass market compact cars and will have a capacity of one lakh units.

Higher Automation

Toyota Kirloskar Motor's Deputy Managing Director (Commercial), Mr Shekar Viswanathan, told Business Line that with the company looking to turn out more cars from the second plant, the auto major was studying the feasibility of automating the plant to a level higher than at the existing plant. "Given the higher volume that the new factory will have, plans to have a higher level of automation in the new factory is under study," Mr Viswanathan said. However, if the cost of automating the new plant is much higher, the company might look at a slightly lower level of automation and hire more workers.

Mr Viswanathan said the company is using the downturn in the auto sector to multi-skill its workers. It is reducing the assembly line speed so that the same number of workers carries out multiple tasks and learns more about taking advantage of the reduction in production because of the slowdown in the automobile market.

Toyota has slowed down production at its plant considerably and expects the plant will return to full capacity in a couple of months. Mr Viswanathan said kaizen (continuous improvement) was an effective process - both during the downturn as well as when the plant is running at full capacity. He said during the downturn, workers will have the

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opportunity to increase their skill sets and will hence be armed to carry out a variety of tasks.

Revival in H2

Toyota Kirloskar Motor (TKM) has said the automobile sector in India is expected to revive by the second half of this calendar year.

The TKM Managing Director, Mr Hiroshi Nakagawa, said the recession had not affected India as it has in other parts of the world. He said the compact car project is on schedule, though it was too early to talk about its pricing.

Mr Nakagawa, speaking on the sidelines of the 18th International Engineering and Technology Fair here, said that Toyota had taken into consideration the fact that when the compact car is launched during 2010, several other car makers too have lined up similar car launches around then. "There will be enough competition by the time we launch our own car. But we expect to have our own niche in the segment," he said.

He said once Toyota starts selling more of these compact cars, it will start work on exporting these cars, though the countries to which these cars will be exported have not been short-listed. The company's Vice-Chairman, Mr Vikram Kirloskar, said one of the reasons for taking the 'top-down' approach in launching mid-sized and multi-purpose vehicles in India was to understand the market better before launching volume-driven small cars. TKM's Deputy Managing Director (Marketing & Sales), Mr Sandeep Singh, said that by the time the new car is launched, the company will have 150 dealers across 100-odd cities. He said the marketing and sales division of TKM was also being strengthened in the run-up to the car launch.

Source: thehindubusinessline.com

1.6 Comparison between Services and Manufacturing

Operations Management is fundamental to an organization's achievement of its mission and competitive goals. It is involved in creating value in the products. Products can be tangible or intangible. Tangible products are called 'goods' or 'manufacturing', while intangible products include 'services'. These are collectively referred to as products.

Effective Operations Management is critical for organizations that provide goods as well as to organizations that provide services and contracts. A firm's success or failure can depend on how it manages operations on a daily basis.

Goods are tangible items that are usually produced in one location and purchased in another. They can be transferred from one place to another and stored for purchase by a consumer at a later time.

Example: Goods are products such as cars, washing machines, televisions, packaged foods, etc.

Services are intangible products that are consumed as they are created. Services now dominate the economies of most industrialized nations. Service organizations include hotels, hospitals, law offices, educational institutions, and public utilities.

Example: They provide such services as a restful and satisfying vacation, responsive health care, legal defense, knowledge enrichment, and safe drinking water.

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Services also include 'back-office' support for internal customers of an organization, such as IT support, training, and legal services. Services take place in direct contact between a customer and representatives of the service function.

Customer contact is a key characteristic of services. A high quality of customer contact is characteristic of a good service organization. This is vital to retain current customers as well as for attracting new ones. Most service organizations, though they seldom carry finished inventory, do have supporting inventory. Hospitals keep drugs, surgical supplies, emergency supplies and equipment spares; banks have forms, cheque books, and other supplies.

Services require more attention and better planning than manufacturing. A manufacturing defect can always be reworked before dispatch. Service, however, occurs in the presence of the service provider, making it difficult to manage capacity and control quality since inventory cannot be stored and inspected prior to the service encounter.

Table 1.1: Comparison between Goods and Services

Operations Factors	Goods	Services
Value	Value is provided by physical processing during manufacturing.	Value is provided by availability of the service, leading to sensory or psychological satisfaction.
Tangibility	Goods are tangible; specifications are easily defined; and goods can be inspected for quality.	Services are intangible; operational characteristics are difficult to specify; and services cannot be inspected for quality prior to consumption.
Process design	Manufacturing can be isolated from the customer and designed for efficiency.	The service process must be designed to occur in the presence of the customer.
Inventory	Products can be stored for later consumption	Services are consumed as they are created.
Capacity	Manufacturing capacity can be designed for average demand.	Capacity must be designed for maximum demand.
Quality	Manufacturing processes can achieve a high level of precision and repeatability.	Consistency of human performance is more difficult to maintain; customer perceptions are subjective
Location	Facilities can be located to minimize operations and transportation costs.	Service facilities must be located near the customer.

Many recent thinkers have suggested that most manufacturing firms are better off thinking of their output in terms of the service bundle they provide to the customer.

Example: Mercedes has announced that it is developing a system that will connect the car's software via the Internet to a customer assistance center. This system will be able to detect, diagnose and repair the problem.

Today, organizations are increasingly trying to grow their presence in the market and earn a competitive edge over competition by mixing goods, and services. This brings in a number of permutations and combination, significantly changing the landscape of operations.

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Notes Xerox has 'redefined' its product as facilitating communications rather than just selling copy machines. In its strategy to be the 'Document Company', Xerox now offers products that can copy handwritten documents, convert them to electronic form, and e-mail them. Such products have allowed Xerox to increase the services related to document management in its output bundle. This type of transition creates significant challenges for Operations Management.

Task Take an example of an airline and show a comparison between its services and manufacturing.

1.7 Competitiveness Strategy and Productivity

"Productivity" relates output to the quantity of resources or inputs used to produce them. It is basically concerned with how efficiently a certain output of goods and services is produced, and the value created by the production process. At the corporate level, productivity makes it possible to produce superior quality and high-value goods and services at the lowest possible cost. If a product could be made at the lowest possible cost with a high quality, and could be sold competitively in the marketplace at a good price, then its productivity would be considered very good. Productivity is expressed with this simple equation:

$$\text{Productivity} = \text{Output}/\ \text{Input}$$

The concept of productivity, however, has evolved over the years to represent more than an efficiency ratio. From cost and quality issues, its scope has expanded to embrace social concerns, such as job creation and security, poverty alleviation, improvement in the quality of life, resource conservation and environmental protection. The role of Green Productivity (GP) has a special significance. "Green Productivity" signifies a new paradigm of socio-economic development aimed at the pursuit of economic and productivity growth while protecting the environment.

Notes The Asian Productivity Organization (APO), Tokyo, Japan launched the GP program in Asia & the Pacific in 1994, in response to Rio Earth Summit of 1992 as a strategy to create a paradigm shift among the stakeholders for productivity enhancement in harmony with environment protection for overall socio-economic development. This comprehensive approach to productivity means that when a corporation implements a productivity improvement program, its effects will extend beyond the company.

There are several concepts of productivity. In addition to the single factor measure of productivity there are also multifactor productivity measures (relating a measure of output to a bundle of inputs). Another distinction, of particular relevance at the industry or firm level, is between productivity measures that relate some measure of gross output to one or several inputs and those which use a value-added concept to capture measurements of output.

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Table 1.2: Overview of Main Productivity Measures

Type of output measure	Type of input measure			
	Labour	Capital	Capital and labour	Capital, labour and intermediate inputs (energy, materials, services)
Gross output	Labour productivity (based on gross output)	Capital productivity (based on gross output)	Capital-labour MFP (based on gross output)	KLEMS multifactor productivity
Value added	Labour productivity (based on value added)	Capital productivity (based on value added)	Capital-labour MFP (based on value added)	-
	Single factor productivity measures		Multifactor productivity (MFP) measures	

Productivity is also used at the national level. Productivity typically is measured as the rupee value of output per unit of labour. This measure depends on the quality of the products and services generated in a nation and on the efficiency with which they are produced. Productivity data is available from different sources for national productivity, for sector-wise as well as industry-wise performance. In improving the standard of living of a nation, productivity is more important than money because productivity determines the output while money just measures the value of the output.

However, the measures that are of relevance here from the point of view of the operations manager are labour productivity, multiple factor productivity and total factor productivity.

Productivity is linked to the competitive strategy of the organisation. Corporate strategy and objectives have a major impact in determining the different operational parameters at the corporate level. There are many other factors and the list may differ from one organization to the next and between different time periods for an organization as well. The principle impact on these parameters comes from competitive strategies.

Corporate strategies and competitive strategies form a hierarchy of strategies. Corporate strategies are concerned with the type of business the organization is in, its overall competitive position and how the resources of the organization have to be deployed. The business strategies are basically competitive strategies. The objectives of these strategies are about how to compete successfully in particular markets, and how can the business units acquire competitive advantage.

Sun-Tzu, a Chinese strategist and general, made an observation in Art of War: "The more opportunities that I seize, the more opportunities that multiply before me." This phenomenon is at the heart of strategy. Organizations compete successfully by seizing opportunities. At the business unit level, the strategic decision that the organization needs to take is 'how will it place its products in the marketplace'? What will be the basis for it to gain competitive advantage? Organizations achieve competitive advantage by providing their customers with what they want, or need, better or more effectively than competitors and in ways the competitors find difficult to imitate. The strategy for each organization is unique reflecting the particular circumstances it faces.

There are two schools of thought on developing competitive strategies. On the one hand, the concept of Generic Strategies is promoted by strategic thinkers like Michael Porter. On the other hand, Prahalad and Hamel promote the "Resource based Approach". However, we will lay greater emphasis on Generic Strategies as these are industry focused and reflect more closely the requirements of the OM Strategy. In order to succeed in this, organizations have found many offensive and defensive actions to defend their position in the industry and cope with competitive forces.

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There are two basic types of competitive advantage a firm can possess: low cost or differentiation. The two basic types of competitive advantage combined with the scope of activities for which a firm seeks to achieve them, lead to three internally consistent generic competitive strategies. These strategies are:

1. ***Cost Leadership:*** A firm pursuing a cost-leadership strategy attempts to gain a competitive advantage primarily by reducing its economic costs below that of its competitors. This policy, once achieved, provides high margins and a superior return on investments.

2. ***Differentiation:*** In a differentiation strategy, a firm seeks to be unique in its industry along some dimensions that are widely valued by buyers. It selects one or more attributes that many buyers in an industry perceive as important, and uniquely positions itself to meet those needs. Differentiation will cause buyers to prefer the company's product/ service over brands of rivals. An organization pursuing such a strategy can expect higher revenues/margins and enhanced economic performance.

3. ***Focus Strategies:*** The generic strategy of focus rests on the choice of a narrow competitive scope within an industry. The focuser selects a segment or group of segments in the industry, or buyer groups, or a geographical market and tailors its strategy to serving them to the exclusion of others. The attention of the organization is concentrated on a narrow section of the total market with an objective of catering to service buyers in the target niche market. The idea is that they will do a better job than the rivals, who service the entire market. Each functional policy of the organization is built with this in mind.

Caution The third type of competitive strategy, focus strategy, has two variants-cost focus and differentiation focus. These strategies can be used by the organization to outperform competition and defend its position in the industry.

1.7.1 Factor Productivity

Labour Productivity

Labour productivity is a single factor productivity measure (relating a measure of output to a single measure of input). Labour productivity is the quantity of output produced by one unit of production input in a unit of time. Average economic productivity is computed by dividing output value by (time/physical) units of input. If the production process uses only one factor (e.g., labour) this procedure gives the productivity of that factor, in this case, labour productivity.

Multiple Factor Productivity

Labour Productivity is only based on observations of volume product outputs and inputs for labour. While the example illustrates the method for calculating productivity, it did not consider that most operations have more than one input and more than one output. In an economic sense, the inputs are:

1. Labour as managers, workers, and externally purchased services,
2. Capital for land, facilities, and equipment, and
3. Materials, including energy requirements.

The importance of these factors may vary widely for companies producing different products. Multiple factor productivity accommodates more than one input factor and more than one output factor when calculating overall productivity. With multiple factor productivity, the outputs can be measured either in money terms or the number of units produced, provided the units can be measured in the same units.

Multiple Factor Productivity = Output (units or value of units)/[Labor + Capital + Materials + Energy + Other]

When more than one input is used for each factor, it is called 'partial'. For example, the Partial Productivity Index of labour is measured by dividing the market value of goods and services produced during the year in the economy as a whole or a particular industry or a firm and dividing it by the number of man-hours taken to produce the goods and services.

Outputs are sometimes difficult to define and measure.

Example: The productivity of a fast-food restaurant could be measured in terms of customers served per hour or by the number of items sold. Both the measures can be misleading because customers may order more than one item and restaurants sell various items (such as drinks, sandwiches, and ice cream) that have different values.

Another issue is that even within the firm, customers of many processes are internal customers, making it difficult to assign a rupee value to the value of process output.

Total Factor Productivity

Total Factor productivity is the year-by-year change in the output where a number of factors are taken into consideration. It is the attempt to construct a productivity measure for an aggregation of factors. Such an aggregation requires additional hypothesis to make it meaningful. These other factors consist not only of investment for education, training, research and development, but also of non quantifiable factors such as the labour relations, climate and worker and management attitudes towards productive efficiency and competitiveness.

Total factor productivity is a more accurate indicator of the economic efficiency of a firm, industry or nation than labour productivity. There are some other limitations to the definition of "Total factor productivity".

Example: It might be the investment made in human beings to raise the quality of labour, or that made to improve productive knowledge through research and development or by the introduction of organizational, managerial and social innovations.

Economic productivity will depend also on pricing and demand. If consumers require fewer products than can be produced, plants will not work at full productive capacity. Thus, economic productivity can well fall with decreasing demand and prices.

Another limitation of this definition is that 'productivity' defined in this manner does not identify whether the change is due to new machinery or more skilled labour force. Both technological and market elements interact to determine economic productivity.

1.7.2 Enhancing Productivity to Gain Competitiveness

Although labour and multifactor productivity measures can be informative, they also can be deceptive when applied to a firm at process levels.

Example: If a firm decides to transfer some of its work to outside suppliers and lay off some of its own workforce, the labour productivity will increase. This is because the value of the firm's total sales (the numerator) remains unchanged while the number of employees (the denominator) drops.

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What is measured and the way in which the processes are managed play a key role in determining productivity improvements. We have to increase the value of output relative to the cost of input. If processes can generate more output of better quality using the same amount of input, productivity increases. If they can maintain the same level of output while reducing the use of resources, productivity also increases. Some of the objectives of improvements in productivity are:

1. Efficiency
2. Maximum output
3. Economy
4. Quality
5. Elimination of waste
6. Satisfaction of human beings through increased employment, income and better standard of living.

From a broader perspective, an increase of productivity is due to a squeeze in waste of resources. The resources may be productive resources, governance, markets or social needs. The real issue is how to achieve them.

Some issues can be simple improvements in the working conditions.

Example: Attention to the details of the production process, like placement of the work piece at the work centre such that it simplifies the job loading of the machine.

This adjustment can be an important contribution in reducing movements and eliminating physical stress, therefore leading to greater output. This type of improvement is important, however, it does not provide the whole picture. The larger picture includes:

1. Issues related to the structure of operations, such as the number size, location, and capacity of the facilities providing the service or producing the products.
2. The equipment and methods used in the activities.
3. The detailed analysis of the individual jobs and activities.

The structure of operations is not as simple as saying that fewer, bigger facilities will result in higher productivity and lower costs. According to conventional economic theory, this tends to be true up to a certain limit. Economies of scale allow firms to increase productivity by making operations larger. Service and manufacturing operations can take advantage of this to improve productivity and lower costs.

Consolidation in the many industries is being driven by the need to spread Fixed Costs, such as information systems, infrastructure, and management, over a broader base of operations. But this action assumes that demand is infinite. Therefore, matching the characteristics of the market to the needs of the customer is crucial. Very often, adding facilities is not the right answer.

Example: When Indian Airlines purchased Boeing aircraft, it arranged for the maintenance of the aircraft to be undertaken by Air India, which already had an established infrastructure. In this way, Indian Airlines avoided duplicating expensive equipment, highly trained staff, and administrative overhead. Similarly, many hospitals are forming alliances with super speciality services to avoid duplication of expensive facilities.

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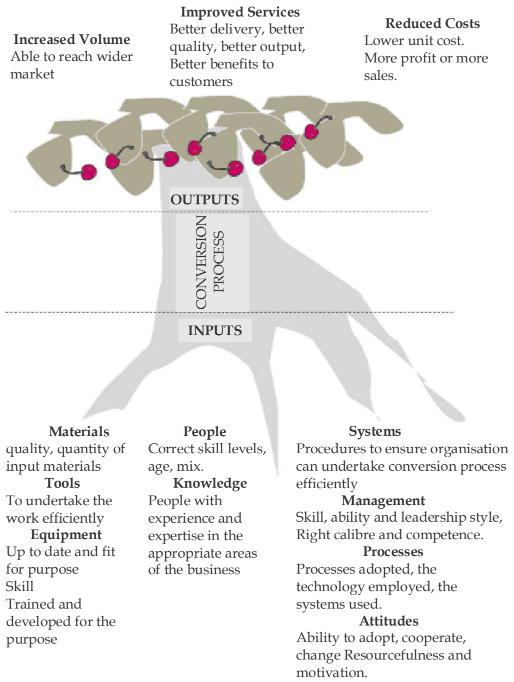
Figure 1.3: The Productivity Tree



Source: http://www.accel-team.com/productivity_01_what.html#

In both these cases, the cost of the service declines and the quality improves.

However, it must be remembered that developments in technology often drive productivity improvements. As organizations invest in technology, they can optimize time, expand options, and reduce costs.

Technology is in many cases revolutionizing business and Operations Management by changing everything from the way products are designed to how inventory is managed and controlled. It is helping in decision making by gathering, organizing, analyzing, and presenting data to managers faster and cheaper each day. This has an impact not only on how effectively and efficiently the equipment is used but also on designing activities that help enhance productivity.

Task Give examples of few companies that have specifically followed cost leadership and focus strategies.

The productivity tree is shown in three parts, the roots (inputs), the trunk (the conversion process) and the fruit (the outputs). As will be recognized in the figure, long-term productivity improvements can be achieved by the human factor through skills, systems, management and positive and innovative attitudes. In this sense, productivity is an attitude of mind which is intolerant of waste of every kind and in any form. It not only refers to work systems but also to the development of right attitudes and a strong concern for efficiency. Waste can be eliminated through:

1. ***Technology, Innovation and Automation:*** Technology, Innovation and automation brings new ideas, methods, and/or equipment to the process of making a product. Technology determines both the maximal physical quantity of output that can be reached as well as the number and the quality of inputs required. This presents an opportunity to cut costs and to

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do more value-added work. The technology that is adopted is an economic choice, taken upon both economic and technological reasons. However, reversibility of the choice is often low because of high switching costs. Business process redesign is another aspect of technology. Technology to improve physical productivity focuses on understanding the diffusion of technology in use and redesigning of processes that exist within and between companies. The rate of technological change varies between industries and the need increases as the clock-speed of the industry increases. Innovative changes in business processes that allow the customer to obtain better value, increases productivity of the organization. Using numerically controlled machine tools can increase productivity and reduce manpower. Similar technologies have been available for decades, but are constantly finding new applications. These reflect exercises in automation as the focus is to substitute capital for labour. It is different from technological innovation because existing automation is merely applied to a new situation.

2. ***Learning and Experience:*** The learning and experience curve concepts have been discussed earlier in detail. This was first observed in the aircraft industry and was found to enhance productivity and reduce costs substantially. The productivity is greatly improved by a distinct form of specialization. As workers learn, they get better trained in the techniques required to do the job. Learning and experience enable firms to achieve productivity improvements because the workforce gains knowledge about the product and work processes. From this knowledge workers find better ways to organize work.

3. ***Job Design, Work Analysis and Motivation:*** All these techniques enable firms to examine work at the level of the individual worker, the interface between a worker and a machine, or the interface between a worker and the firm. The job design and work analysis approach investigates and improves individual movement to improve productivity. It makes possible productivity improvements through scientific redesign of the work content. Job design and work measurements also provide benchmarks that can be powerful motivators. Motivation is a powerful tool that can be used to increase productivity in any job that is labour intensive.

Firms can also provide incentives to increase workers' productivity through a stimulating environment and the removal of obstacles to their effective work. The classical Hawthorne Studies by Elton Mayo showed that if labour is motivated to do more work, productivity can increase without additional investments or cost increases.

Example: When the lighting levels in the Hawthorne works were improved, there was increased productivity with no additional costs.

1.7.3 Productivity in Manufacturing versus Service Firms

Productivity applies equally to the blue-collar workforce as to people doing intellectual work. In many developed countries, blue-collar workers represent a small and declining portion of the workforce and the dominant workforce is represented by intellectual work in service organizations. This change is explained by a change from a manufacturing to service-based economy in these countries. The problem presented by this shift is that productivity gains in the service sector have lagged behind gains in the manufacturing sector.

Nobel Prize-winning economist Robert Solow has said that we see computers everywhere except in the productivity statistics. That productivity measures do not seem to show any impact from new computer and information technologies has been labelled the "productivity paradox". Several explanations have been advanced to explain this lag, including ineffective measures for services sector productivity and macroeconomic factors, such as the low savings rate while on the other hand fear of job loss by manufacturing workers, which motivates them to work harder and smarter.

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However, there are many examples from leading-edge service companies that have achieved dramatic improvements in productivity while other firms within the same industry have lagged. In many cases, these competing companies use the same basic technology, pay the same wage rates, and operate under the same basic labour agreement. This contradiction is often explained by lack of intelligent focus in the use of new technologies.

The animating force for productivity and wage growth in the new economy will be the pervasive use of digital electronic technologies. This is expected to increase efficiency and productivity, particularly in the low-technology service sector.

It is forecasted that with increased learning, the digitization of the economy in the 21st century will bring in the kind of economic benefits that mechanization brought in the 20th. And this will be spurred by the "network effect" – the more we use these technologies (e.g., Internet, smart cards, broadband and telecommunications), the more applications will be developed, and the more value they will provide for users. Once this occurs, the productivity paradox could very likely give way to a productivity and wage boom.

1.8 Computing Productivity

Effectiveness of production management is measured by the efficiency through which the inputs are converted into outputs, i.e., effectiveness of outputs and inputs. This efficiency is called productivity of the system. The higher the productivity, the more efficient is the production system.

Conceptually, productivity is defined as an attitude of mind and prevention of all kinds of waste. Mathematically,

Productivity = Output/Input = Goods or Services Produced/All Factors of Production

1.8.1 Productivity Indices

When both output and input are expressed in the same unit, productivity reduces to a mere number. Quite often it is expressed as a % of output to input. It is also expressed as:

OMS : Output per man-shift

Example: A coalminer produces coal @ 2 tonnes per day, we say that his OMS is 2t/day.

Production per month:

1. For better understanding in an industry, e.g., in a steel plant, it is expressed as 10,000 tonnes (of steel produced) per month.
2. GNP (Gross National Product): National productivity is given as per capita income.
3. In agriculture sector: Output per hectare, etc.

For industries having incentive Schemes:

Productivity = SMH/AMH

= Standard Man-Hours Earned/Actual Man-Hours Worked

1.8.2 Wastivity

Wastivity = 1/Productivity

Another way of looking at the concept of productivity is to look at the amount of wastage generated in the system. The wastage could be an unnecessary input, a defective output, idling

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of the resources, etc. If we could measure these wastages and have a measure of the wastage, then it becomes a tool for measuring the efficiency of the inputs called "Wastivity".

Example: The typical examples of wastes are:

1. Idling of resources, e.g., materials waiting in the form of inventory in the stores, machines waiting to be loaded, job orders waiting to be processed, patients waiting for service at a doctor's clinic customers waiting for reserving a berth/seat at a reservation counter.
2. Production of defective goods and services, e.g., components/parts not conforming to specifications, higher conversion costs resulting from inefficient/poor methods of working or process not set correctly, poor quality of materials used, excessive maintenance delays, etc.

For an effective and efficient production system, wastage of all kinds must be eliminated or at least minimised.

Checklist for above can be prepared through the parameters responsible for wastage generation and fixing standards from time to time.

Reduction of scrap or rejections, or percentage increase in yield, just by one (1) % can save an organisation tremendously as compared to an increase in production and sales efforts by at least 10-15 %.

Productivity can be increased by any of the following three ways:

1. By increase of output, keeping input constant.
2. By decreasing inputs for producing the same output.
3. By increasing outputs proportionately higher than increases affected in inputs.

Various factors contributing to increase of productivity can be summarized as below:

1. Better utilisation of resources like men, machines and materials.
2. Using efficient and effective methods of working.
3. Through good and systematic plan-layouts using guidelines and principles of motion-economy.
4. Reducing material handling through better layouts and using appropriate material handling equipments/facilities.
5. Selection of appropriate technology suiting the product(s) and the production process selected.
6. Selection of proper maintenance policy, keeping in mind the service level, preventive maintenance and breakdown maintenance.
7. Provision of healthy and safe working conditions to workmen.
8. Through modern HRM methods; management by MBO rather than management by crisis, counselling rather than threatening workmen – through participation of workmen in management including quality circles etc. This shall ensure better working environment and keep the workforce motivated.
9. Provision of fair wages and proper compensation through incentive schemes.
10. Through better quality by use of SQC techniques sampling plans in purchase and statistical process control in production.

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Example: In a manufacturing unit, the standard time allowed for the production of a unit is 5 hrs. If in a particular month 126 units are produced by employing 4 persons and the allowable delays are found to be 44 man-hours, find the productivity and wastivity of the concern.

Solution:

ESH = Earned Standard Hours

STD Time/Unit = 5 hrs

Production = 126 units

Earned standard man-hours = 5 × 126

= 630 hrs

AMH = Available Man-hours

Manpower Employed = 4 P

Monthly working hrs = 4 × 25 × 8 = 800 hrs

Allowed delays = 44 hrs

Therefore, AMH = Actual Man-hours available for production

= (800 – 44) hrs

= 756 hrs.

Therefore, Productivity = (ESH/AMH) × 100

= (630/756) × 100

= 83.33% Ans

Wastivity = 100 – 83.33

= 16.67%

Case Study

The Bicycle Ride

TI Cycles was promoted by the family of Murugappa Chettairs in September 1949. The company was a collaboration formed with Hercules Cycles & Motor Co. of U.K., to indigenously produce complete bicycles and bicycle parts, and substitute imports. The bikes that TI Cycles manufactured were elegant, well-built and based on British designs. They had immaculate reputations for quality and durability. For almost forty years, the name "BSA" and "Hercules" were synonymous with value. The future looked bright. Generations of kids learned how to ride on elegant BSA or Hercules bikes. A good bike enters the life of a child like a good friend, and many of these kids grew up to be parents—parents who wanted their kids to ride these bikes.

However, over the 1970s and 1980s, the market for bicycles was changing but TI Cycles seemingly did not quite understand what was happening. In Ludhiana, Hero Cycles grew from its origin as a small producer of bicycles to the largest manufacturer of bicycles, right under the nose of TI Cycles. At the heart of Hero Cycle's success lay a different value creating logic. Hero Cycles developed their cycles to meet specific Indian needs. They designed a cycle that could carry two people plus a heavy load at the cheapest price. They

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were not elegant products like BSA or Hercules, but they were designed for farmers to carry heavy load of vegetables to the village market.

In 1944, four Munjal brothers, headed by Shri Brijmohan Lal Munjal, came to Amritsar from a small town called Kamalia, now in Pakistan. They decided to start a business of bicycle spare parts in Amritsar. This business evolved into Hero Cycles. The Munjal family created a local component infrastructure by inducing friends and family members to set up ancillary units. They developed a policy of supporting these units with both funds and technical assistance. Much before Just-in-Time production became popular; they adopted the system, leading to extremely low costs that allowed them to cut TI Cycles prices by 15 to 20 per cent even on the cheapest models. Over the years, it became active in both standard and speciality bike segments. In 1989, it launched Hero 'Ranger' to satisfy the need that TI had overlooked—cycles for peddling on rugged terrain. It created a new category of Mountain Terrain Bikes (MTB). Hero had further built its market position by introducing fitness bikes under the brand name Hero 'Allegro'.

One executive at TI Cycles remarked, "Since our company had started the industry in India, the general psychology inside TI was that the leadership position would continue owing to the technical sophistication of the product. Hero Cycles intuitively learned to make the cycles on its own and offered value for money. It competed on price and tapped the price conscious segment".

TI Cycles had failed. Its failure illustrates two facets of the business environment. The first is the phenomenon called 'customer disconnect'. This company had fallen so deeply in love with what it had been that it no longer listened to what its customers and the bicycle market wanted. TI Cycle's greatest failure was that it no longer understood its customers' values.

Secondly, TI Cycles failed to see the disruptive forces that were changing its industry. The values of its customers were changing. TI Cycles could not fathom the changing values. New bicycle firms were assembling a wide range of products, often using highly engineered components made by others. TI Cycles took pride that it made all of its components. It could not see the merits of buying components from outside suppliers. But the new breed of cyclists started to buy lower cost bikes through the same marketing channel that heretofore had sold TI Cycles.

In 1994-95, the family dominated board of directors had to wake up to the problem. The total loss from operations of TI Cycles was ₹ 2.98 crores on a sale of ₹ 208.28 crores. It had slipped to the number three position in the industry. Its sales in the domestic market had flattened out. The management had to admit that they needed to totally rethink their concept of the markets, customers and competitors. They had to change their supply chain philosophy, and follow a different path.

This led to the initiation of a series of measures at TI Cycles in product development and manufacturing. In early 1995, TI Cycles introduced the first bike with front shock absorbers and in 1995 Rockshok FST with front and rear shock absorbers. In 1998, it created a category of geared bikes under the Hercules 'Top Gear Brand'.

In the area of manufacturing, the company took steps at shop-floor restructuring, and sourcing. As a part of an initiative, TQM was introduced in TI Cycles in January 1998. A series of small group activities and cross-functional teams were introduced in the company. The company obtained the ISO 9000 certificate in March 2000. In response to these measures, productivity per man per day increased from 2.45 cycles in 1994-95 to 5.78 in 1999-2000.

In 1998, TI Cycles proposed to AVON Cycles, one of the smaller players in Ludhiana, that they would provide help in assembling the bike and in ensuring quality and market it

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under 'TI Cycles' brand. This proposal enabled AVON to utilize its capacity and TI Cycles to obtain standard cycles at a lower cost. With a view to further improve its cost competitiveness and delivery, TI Cycles started a unit in Nasik, Maharashtra in 2000, to paint and assemble bicycles and cater to the needs of the Western and Northern markets. Thus has begun an attempt by one of the great companies to make a come back.

Essentially, an organization must address two questions: "Who are we?" and "What do we want to be?" This is the mission of the organization and it defines its reason for existence. It might include a definition of products and services it provides, technologies used to provide these products and services, types of markets, important customer needs, and distinctive competencies—the expertise that sets the firm apart from others. The mission guides the development of strategies by different groups within the firm.

1. It determines the value creation logic of the organization;
2. Sets limits on available strategic options;
3. It governs the trade-offs among the various performance measures and between short-and long-term goals;
4. It establishes the context within which daily operating decisions are made; and
5. It inspires employees to focus their efforts toward the overall purpose of the organization.

TI Cycles provided value to its customers by producing elegant, high quality bicycles. To implement this strategy of producing high quality, beautifully designed cycles, TI Cycles adopted a policy of vertical integration. It produced most of the components in-house, all the way down to the steel tubes required for the bicycle frame. It created organizational values and people processes that supported the vision of the organization.

Hero Cycles, on the other hand, had a fundamentally different value creation logic. It manufactured heavy duty, low cost bicycles. Hero Cycles outsourced most of the components. It focused on creating a highly efficient assembly operation in-house. Both organizations were good at what they were trying to provide. Where did TI Cycles go wrong?

One executive at TI Cycles analyzed the situation as follows, "We have continued to maintain our position in our market segment. Hero Cycles tapped the price conscious segment which turned out to be the largest market segment in the industry and is the leader in that segment. We did not see that market segment becoming so big, nor did we believe that we could compete on price with Hero Cycles".

A clear understanding of the implications of strategic choices on operational capability is vital to success. Without the capability to produce low cost products, no amount of dreaming would have made Hero Cycles capable to provide a product to replace the BSA and Hercules bicycles. Their ability to design bicycles that met India specific needs at low cost made it possible for them to provide the right product at the right time and make them market leaders.

TI Cycles operational strategy of producing elegant, high quality bicycles became the corporate strategy of the company. This resulted in its inability to compete with Hero Cycles. It did not develop the capabilities to compete on price, and hence it could not provide value when there was a shift in the needs of the market.

Questions

1. How did TI cycle loose its way?
2. Analyse the bicycle market in India.

Notes

1.9 Summary

- Operations Management is the management of an organisation's productive resources or its production system, which converts inputs into the organisation's products and services.
- Production may be defined as the conversion of inputs – men, machines, materials, money, methods and managemen (6 Ms) into output through a transformation process.
- Production is a primary business function along with marketing and finance, other management areas being HRD (Personnel & Industrial Relations) and Materials Management, etc.
- The major objective of production management is to produce quality goods and services.
- Production management is viewed as a continuous process of planning, organising and controlling.
- Automation is the self-controlling operation of machinery that reduces or dispenses with human communication or control when used in normal conditions.
- Operations Management is fundamental to an organization's achievement of its mission and competitive goals.
- Products can be tangible or intangible. Tangible products are called 'goods' or 'manufacturing', while intangible products include 'services'.
- Customer contact is a key characteristic of services. A high quality of customer contact is characteristic of a good service organization.
- "Productivity" relates output to the quantity of resources or inputs used to produce them. It is basically concerned with how efficiently a certain output of goods and services is produced, and the value created by the production process.
- There are several concepts of productivity. In addition to the single factor measure of productivity there are also multifactor productivity measures.
- Productivity is also used at the national level. Productivity typically is measured as the rupee value of output per unit of labour.
- Productivity is linked to the competitive strategy of the organisation. Corporate strategy and objectives have a major impact in determining the different operational parameters at the corporate level.
- There are two basic types of competitive advantage a firm can possess: low cost or differentiation.
- Effectiveness of production management is measured by the efficiency through which the inputs are converted into outputs, i.e., effectiveness of outputs and inputs.

1.10 Keywords

Automation: Act of converting the controlling of a machine or device to a more automatic system.

Cost Leadership: A firm attempts to gain competitive advantage by reducing its economic costs below that of its competitors.

Differentiation: Firm seeks to be unique in its industry along some dimensions that are widely valued by buyers.

Focus Strategy: Choice of a narrow competitive scope within an industry.

Green Productivity: It signifies a new paradigm aimed at the pursuit of productivity growth while protecting the environment.

Labour Productivity: Quantity of output produced by one unit of production input in a unit of time.

Manufacturing: Tangible items that are usually produced in one location and purchased in another.

Operations Management: Management of an organisation's productive resources or its production system.

Production: Conversion of inputs – men, machines, materials, money, methods and management (6 Ms) into output through a transformation process

Productivity: Output/input

Services: Intangible products that are consumed as they are created.

Total Factor Productivity: Year-by-year change in the output where a number of factors are taken into consideration.

Wastivity: 1/productivity

1.11 Self Assessment

State whether the following statements are true or false:

1. Behavioral Management believes that management is a continuous process.
2. The techniques adopted for production of goods is one of the major inputs that can increase productivity.
3. The costs of automation is comparatively is more cost effective in the long run.
4. It is easier to handle the operating procedures of intangibles rather than taking care of the goods.
5. Productivity is only measured in terms of output and inputs.
6. Brands like Tag Heuer and Rolls Royce follow a focused strategy.
7. Multiple factor productivity is same as the total factor productivity.
8. Per Capita income indicates the national income of an economy.
9. The breaks given to the employees at work leads to wastivity of resources rather than increasing productivity.
10. The management functions like finance, HR, marketing etc. play an important role in enhancing productivity of the workforce.

Fill in the blanks:

11. ……………………branch of management stresses on use of mathematics in management.
12. Increasing productivity not only from production or output point of view but also socio-economic point of view is known as……………………
13. Big Bazaar in India and Wal-Mart worldwide is following a …………………..strategy to gain competitive advantage.

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14. Fiat has given the marketing rights of its cars in India to………………..to increase their productivity.
15. A labour in the field sows seeds in 1.5 hectares of land in a day. This is known as ……………………

1.12 Review Questions

1. "Men supervise machines and are supervised by them as well". Discuss.
2. Do you think production is much more complex than producing output? Give reasons.
3. Write short notes on all the major inputs required for production (6 Ms).
4. How would you connect production with marketing, HR, finance and materials management?
5. "The major objective of production management is to produce quality goods and services". Does this hold good in modern scenario? Give examples of companies that have deviated form this.
6. "Production management is viewed as a continuous process of planning, organising and controlling". Substantiate.
7. Has automation helped humans by reducing their burden or it has taken away their efficiency by making them dependent on machines? Validate your argument.
8. "Automation is directly linked to unemployment." Comment.
9. Why is mastering a service organisation is much more difficult than manufacturing? Why has service become so important?
10. "Productivity is linked to the competitive strategy of the organisation". Discuss.
11. How can organisation's calculation based on labour productivity be deceptive? What other method do you suggest?
12. "The structure of operations is not as simple as saying that fewer, bigger facilities will result in higher productivity and lower costs". Elucidate.
13. Explain the concept of productivity tree.
14. "Productivity can be defined as an attitude of mind". Discuss.
15. Calculate wastivity from the following:
    (a) Acceptable time for producing a single unit: 3 days
    (b) Output produced in a month: 450 units
    (c) No. of employees: 12
    (d) Delay allowed: 60 man hours

Answers: Self Assessment

1.	False	2.	True
3.	True	4.	False
5.	False	6.	True
7.	False	8.	True

Notes

9. False
10. True
11. Modelling
12. Green Productivity
13. Cost Leadership
14. Tata Motors
15. Output per Man Shift

1.13 Further Readings

Books

Chase, Richard B., and Eric L. Prentis, *Operations Management: A Field Rediscovered,* Journal of Management, 13, no. 2 (October 1987): 351: 366

Hayes, Robert H., *Towards a 'New Architecture' for ROM,* Production and Operations Management, 9, no. 2 (Summer 2000) 105-110.

Schonberger, Richard J., *World Class Manufacturing: The Next Decade,* New York: The Free Press, 1996.

Online links

managementhelp.org/ops_mgnt/ops_mgnt.htm

www.knoah.com/images/pdf/operation/productionmanagement

www.pcmag.com/.../0,2542,t=automation&i=38258,00.asp

ezinearticles.com/?The...of-Measuring-Productivity&id

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Unit 2: Product and Service Design

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Objectives

Notes

After studying this unit, you will be able to:

- Discuss the objectives of designing
- Understand legal and environmental issues
- Explain Lifecycles
- Describe product design and development
- Define delayed differentiation
- Discuss commonality
- Explain the mass customization
- Define standardization
- Discuss the modular design and service design
- Explain design for manufacturability
- State differences between manufacturing and service design
- Define reliability
- Discuss computer-aided design

Introduction

Product decisions often make or break companies. Studies indicate that nearly two out of three new products fail after launch. In addition, companies in many sectors are under continual pressure to speed up the pace of product development – even to adapt products that are still in the pipeline to the demands of a constantly changing marketplace. This unit will discuss product and service design, which are crucial areas in operations management.

2.1 Objectives of Designing

The objectives of product and service design can be divided into two broad categories:

1. ***Main Focus:***
   (a) Customer Satisfaction
   (b) Understanding what customer needs
2. ***Secondary Focus:***
   (a) Function of product/service
   (b) Cost
   (c) Profit
   (d) Quality
   (e) Appearance
   (f) Ease of production/Assembly
   (g) Ease of maintenance/servicing

Notes

2.2 Legal and Environmental Issues

The major legal issues are:

1. ***Patents:*** A patent is a grant of property rights by the government to an inventor. Patents are exclusive property rights that can be sold, transferred, willed, licensed or used as collateral, much like other valuable assets. In fact, most independent inventors do not commercialize their inventions or create new products from their ideas. Instead, they sell or license their patents to others who have the resources to develop products and commercial markets. Patent law stipulate broad categories of what can and cannot be patented and in the words of the statute, any person who "invents or discovers any new and useful process, machine, manufacture, composition or matter or any new and useful improvement thereof, may obtain a patent."

2. ***Trademarks:*** It includes any word, name, symbol, distinguishing device or any combination thereof adopted and used by a manufacturer or merchant to identify his goods as distinguishing them from those manufactured or sold by others.

Example: Trademarks can be names used in commerce such as Coke, clearly trademarked by the Coca-Cola Corporation. A trademark can be a symbol like Apple Computer Corporation's unusual apple with a bite in the side. A distinguishing device can be artistic renderings of corporate products, such as the wild mustang horse for the Ford automobile, the intricate shield and insignia designed NFL football team.

3. ***Copyrights:*** A copyright extends protection to authors, composers, artists and it relates to the form of expression rather than the subject matter. This distinguishing feature is important because most intellectual property has proprietary information in terms of subject matter and if that property cannot be patented, the copyright only prevents duplicating and using the original matter. The probation does not prevent another person from using the "subject matter" or rewriting the material.

Example: The concept of an electronic spreadsheet is not protected; however the software program devised to create the spreadsheet (form of expression) is protected by copyright.

4. ***Product Liability:*** It refers to the responsibility of a manufacturer or vendor of goods to compensate for injury caused by defective merchandise that it has provided for sale.

   When individuals are harmed by an unsafe product, they may have a Cause of Action against the persons who designed, manufactured, sold, or furnished that product.

Notes In the United States, some consumers have hailed the rapid growth of product liability litigation as an effective tool for Consumer Protection. The law has changed from caveat emptor ("let the buyer beware") to Strict Liability for manufacturing defects that make a product unreasonably dangerous. Manufacturers and others who distribute and sell goods argue that product liability verdicts have enriched plaintiffs' attorneys and added to the cost of goods sold. Businesses have sought TORT reform from state legislatures and Congress in hopes of reducing damage awards that sometimes reach millions of dollars.

5. ***Uniform Commercial Code:*** Created in 1952, the Uniform Commercial Code (UCC) consists of uniform acts coordinating the sale of goods and other commercial transactions throughout

the 50 United States. The Uniform Commercial Code also seeks to make commercial paper transactions, such as the processing of checks, less complex. It distinguishes between merchants, who know their business well, and consumers, who do not. Overall, the code's objective is to eliminate the need for lawyers in the aspects of commercial trade it governs.

The main environmental issues are:

Environment Protection Act has been enacted to provide for the protection and improvement of environment and for matters connected therewith.

Whereas the decisions were taken at the United Nations Conference on the Human Environment held at Stockholm in June, 1972, in which India participated, to take appropriate steps for the protection and improvement of human environment; And Whereas it is considered necessary further to implement the decisions aforesaid in so far as they relate to the protection and improvement of environment and the prevention of hazards to human beings, other living creatures, plants and property. Subject to the provisions of this Act, the Central Government shall have the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing controlling and abating environmental pollution. Where any offence under this Act has been committed by a company, every person who, at the time the offence was committed, was directly in charge of, and was responsible to, the company for the conduct of the business of the company, as well as the company, shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly:

Provided that nothing contained in this sub-section shall render any such person liable to any punishment provided in this Act, if he proves that the offence was committed without his knowledge or that he exercised all due diligence to prevent the commission of such offence.

2.3 Lifecycles

2.3.1 Product Lifecycles

The product lifecycle model is a simple representation of the cumulative impact of changes in the business environment on the life of a manufactured product. It is an important management tool to understand the product and its finite lifespan and develop the understanding of the situation so that strategies for survival and growth can be effectively advanced.

A product category goes through four stages of development.

Stage 1: Product Introduction Stage

During this stage, the product is new to the market and the consumers have to be motivated to try and accept the product. This is a stage when the product volumes are low and profit is normally down.

Stage 2: Growth Stage

As the product finds market acceptance, it goes into the growth stage. During this period, there is an exponential growth of the volumes accepted by the market. New competitive products are introduced and there is a significant change in the product features due to continuous improvements.

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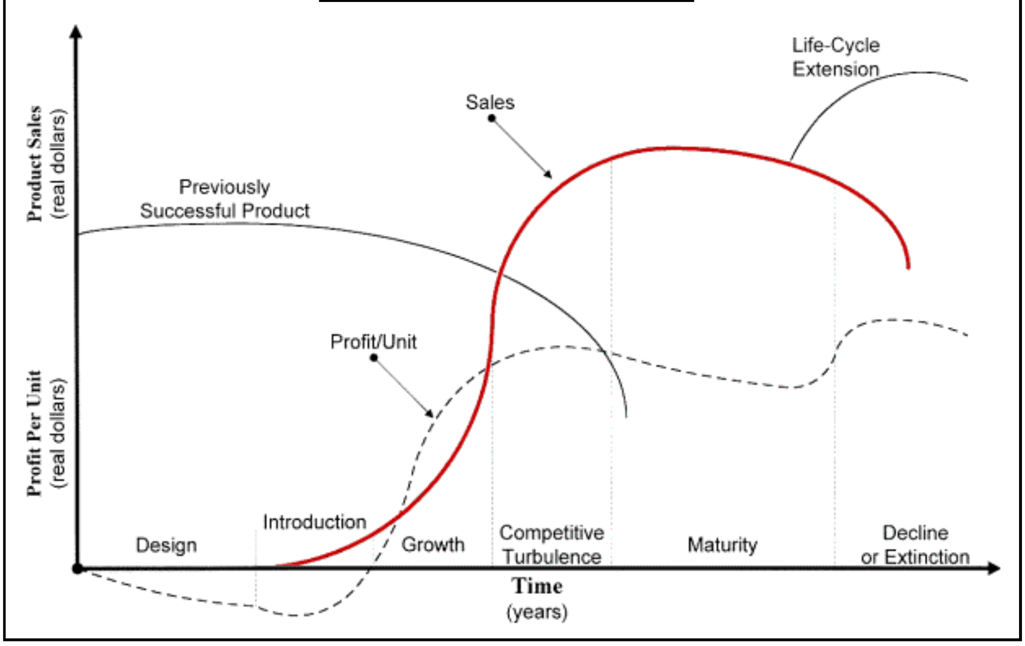
Stage 3: Maturity Stage

The third stage or the maturity stage sees the product as an established product and the demand and quality of the product does not undergo much change. However, this is the stage of cut-throat competition, with competitors competing on the basis of providing value to the product.

Stage 4

In this stage, new product categories are introduced into the market that provide better value to the consumer for that particular need or there is a change in the needs of the consumer.

Figure 2.1: Product Lifecycle



A number of factors impact the product category when it is introduced. Factors that impact the introduction stage of consumer products positively are:

1. Relative Advantage
2. Compatibility (values and experience of adopters)
3. Divisibility (ability to try on a limited basis)
4. Communicability, i.e., ability to describe advantages.

Factors that impinge negatively are:

1. Complexity
2. Perceived Risk

In the case of industrial products, though the principles involved are similar, the mechanism by which it works is different. It has been found that the rate of diffusion in industrial markets, during the 'introduction stage', is related to the competitive intensity of the supplier industry, the reputation of the supplier industry, and the vertical co-ordination between supplier and adopter industries.

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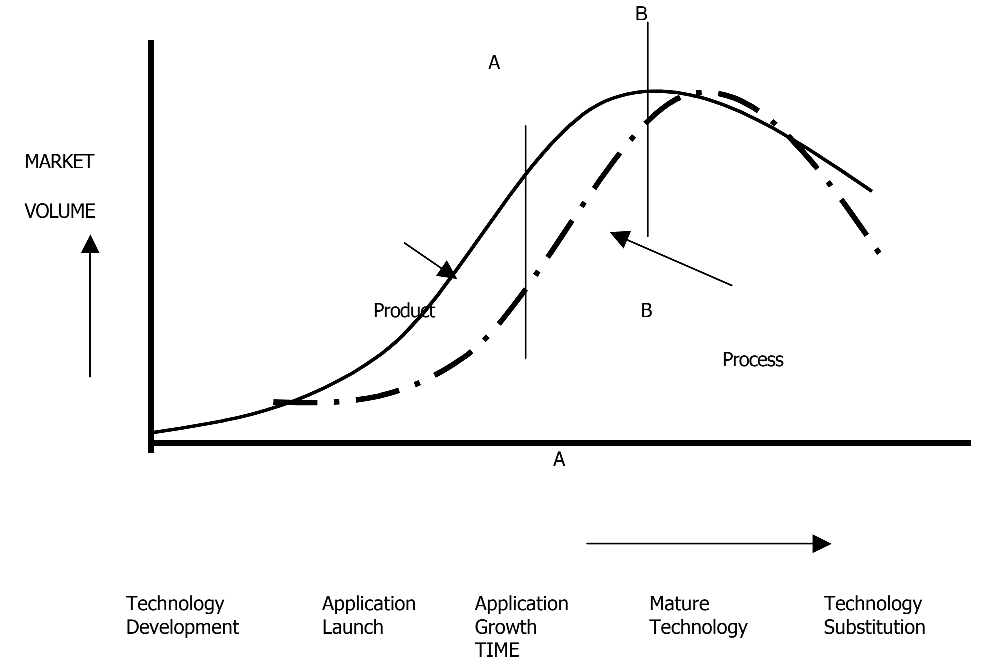
2.3.2 Technology Lifecycle

Statistical regularities show that the product lifecycle can be used to forecast the way the product attributes, demand, production and competition will change as the product matures. A related and more useful concept is the technological lifecycle. This links market growth and technology.

Figure 2.2: Technology Lifecycle



It has been seen that technological change generally follows the course described by the 'technology lifecycle' graph. By plotting the market volume over time for any industry, one can identify the changes in the industry. This is called technological aging of the industry. This exercise can be carried out both for the product as well as the process and has been depicted in Figure 2.2. When a new industry based on new technology is begun, there will come a point in time that one can mark as the inception point of the technology.

Lets us discuss the various phases of technological aging/lifecycle by taking up the example of the automobile industry. In 1887, Gottlieb Daimler manufactured the first gasoline-powered automobile.

Phase I: Technology Development

1. Then the first technological phase begins with the rapid development of the new technology. This phase is called the Technology Development phase. In the case of the automobile, it would be from 1887 to 1902, as experiments with steam, electric and gasoline powered vehicles were conducted.
2. This is an exciting time, because product improvements continue and improved processes for producing cheaper, better products are innovated.
3. This is the time of eliminating weak competitors.

Example: In 1909 there were 69 auto-manufacturing firms in USA. Only half the firms survived by 1916.

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Phase II: Applications Launch

This phase is the creative period of product experimentation. This lasts till the time a standard design has been worked out and rapid growth of the market begins. This occurred with Ford's Model T design. During this phase, failure rate of firms in the industry continues to be high, but successful firms grow. Corporate R & D becomes important to maintain incremental model improvements. For example, by 1923 only eight major American firms had remained in the automobile industry, capturing 99 per cent of the market.

Phase III: Applications Growth

1. During this phase there is a rapid growth in the penetration of technology into markets.
2. After some time, however, the innovation rate slows down and the market peaks; no new markets are created.

Phase IV: Mature Technology

1. In this phase, process innovations are dominant.
2. Very few firms survive, of the original lot.
3. Competition is primarily on price and segmented market lines.
4. Production is specialized and efficient.
5. Economies of scale and marketing dominance continue to whittle down competitors, to the final few.

Example: By 1965, only General Motors, Ford, Chrysler, and American Motors had survived in the American automobile industry.

A mature industry can continue indefinitely. Competitors with more abundant resources, cheaper labour or subsidized capital can obtain a competitive advantage. When market saturation is taking place, it is important to continue technological innovation to extend the product life and delay market saturation. Innovation succeeds in:

1. Creating succeeding generation products with significantly improved performance,
2. Creating multiple applications,
3. Lowering of price to facilitate ownership of multiple copies of the product for convenience.

Phase V

Finally, competing or substituting technologies overrun the mature technology and the last phase is reached. At this stage, the industry has run out of significant innovation. Changes in demography, replacement and foreign markets now primarily determine the market size.

2.3.3 Product Lifecycle and Technology Lifecycle

The length and pattern of the Product Lifecycle can vary significantly. There is no reason to believe that all products inevitably pass through all four stages, e.g., fad items, consumer resistance, and introduction of superior new product. Though the Product Lifecycle diagram has been designed for product categories, it has limited use to management, as it may not reflect the life of their 'Product Form', or 'Brand'.

The reliability and the interpretation of the Product Lifecycle for analysis of product brands is a serious limitation of this instrument. However, it can be used for 'product forms' quite successfully.

Example: Product Form – Filter Cigarettes.

Product Brand – Classic Mild.

The Product Lifecycle concept is extremely useful. It shows how customers tend to be much more knowledgeable about the product class as the lifecycle progresses; product performance typically improves over the cycle and the relative differences in brands competing for the same segment decline as successful ideas are copied. This leads to increased competition based on price, image, service, durability, reliability, etc., which results in increased value to the consumer.

Simultaneously, with the technological changes in the lifecycle of the product, changes also take place in the process. The changes are slow at first during the period that the product volumes increase, but are maximized during the phase that the product reaches the maturity stage. In other words, the growth stage of the process technology normally coincides with the maturity stage of the product.

The growth stage of the technological process is between the lines AA and BB in Figure 2.2, which coincides with the maturity stage of the product technology. Technology improvements take place until such time that the process becomes so efficient that any marginal increase in the parameters of the process would not provide the required returns. As improvements continue, the investment in small improvements becomes so large that they are not economically justified. This reflects the downturn in the process technology curve.

The fact that the rates of technological innovation affect the competitive conditions of an industry means that management should plan different strategies for different phases of the technology lifecycle.

Example: It is suggested that in times of changing technology, management should use the technology lifecycle model to arrive at decisions regarding the technologies, new products, etc., that it requires for its future growth and survival.

A general strategy of phasing new products in and phasing old products out sustains the existing process capacity.

2.4 Product Design and Development

Without products, there would be no customers. Without customers, there would be no revenue. Developing a new product is a major activity. Thomas Alva Edison, with as many as 1,300 inventions and 1,100 patents to his credit, said about the product development process, "Genius is 1 per cent inspiration and 99 per cent perspiration." Product development requires more of perspiration and less of genius to be successful. Leaders today still use four key components of Edison's product development model:

1. ***Lofty Goals:*** For example, the ability of the bulb to stay lit for long periods of time.
2. ***Right to Left Process:*** Start with customers and move backward through operations to design.
3. ***Structure:*** Have 'clear targets' instead of daydreaming and aimless experimentation.
4. ***Fluidity:*** Be driven by talent, not hierarchy.

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Many designers do not understand these issues and, as a result, often propose products that cannot be produced or service designs that cannot be delivered because of inadequate technology or operational capabilities. The approach to product development has to start with an evaluation of the capabilities and resources of the organization.

The new product strategy of the organization is decided on the basis of organizational capabilities and resources. Organizations should develop explicit product-development strategies to co-ordinate all of the major business processes that contribute to product innovation. The need to be fast when competing in high clock-speed industries makes this an absolute necessity.

With a new regime of patents and legal protection against copying ideas, designs, or products– there have been changes in the approach to new product development. Organizations are more concerned about being the first to develop an idea or design a product so that they can protect their markets.

Being able to design, develop, and introduce a new product quickly gives a firm 'fast to market' capabilities. There are two types of fast to market activities.

1. ***Fast to customization:*** The first activity is being able to develop products to meet the specific needs of a customer. This is called fast to customization. Producing such a product with the participation of the customer, may give a firm a competitive advantage.

2. ***Fast to design:*** The second type relates to developing products to meet the needs of a cluster of customers. Fast to design product innovation can be used in MTS, ATO, and MTO market orientations.

Example: Nokia introduced cell phones that incorporate cameras. Seeing that there was a cluster of customers for this product all manufacturers now offer this product. Nokia has a first mover's lead in this segment of the market.

In other situations, being fast to market may not be less important. It depends on how quickly a product's design becomes stale. Mercedes-Benz traditionally had customers that valued good design more than a model a year.

For some products, being fast to market may not be in your firm's best interest.

Example: A creative advertising executive always makes his clients wait a week or two, even though he thought of the copy for the ad in a day. Likewise, if a gourmet restaurant that serves your meal five minutes after you order, you know that they must be using a microwave oven. If they make you wait for 30 minutes, then the same judgment cannot be made.

Another important type of product innovation involves refining or rejuvenating products within the existing product line. For some companies, this is an annual event, as is the case with the automotive industry.

Major redesigns in the automobile industry can take years and costs billions. This becomes a Catch-22 situation. Since it costs so much to develop new models, auto companies often try to sell as many copies of the new product as possible, even if it takes four or five years. But the older a car's design gets, the greater the chance that it will lose market share to competitors with fresher models. And worse yet, if it takes five years to develop a new model and a company wants to sell that model for another five years, then it must project what the customer's preferences are likely to be ten years from now. This is not only a tremendous challenge, it requires a leap of faith to take it to its logical conclusion.

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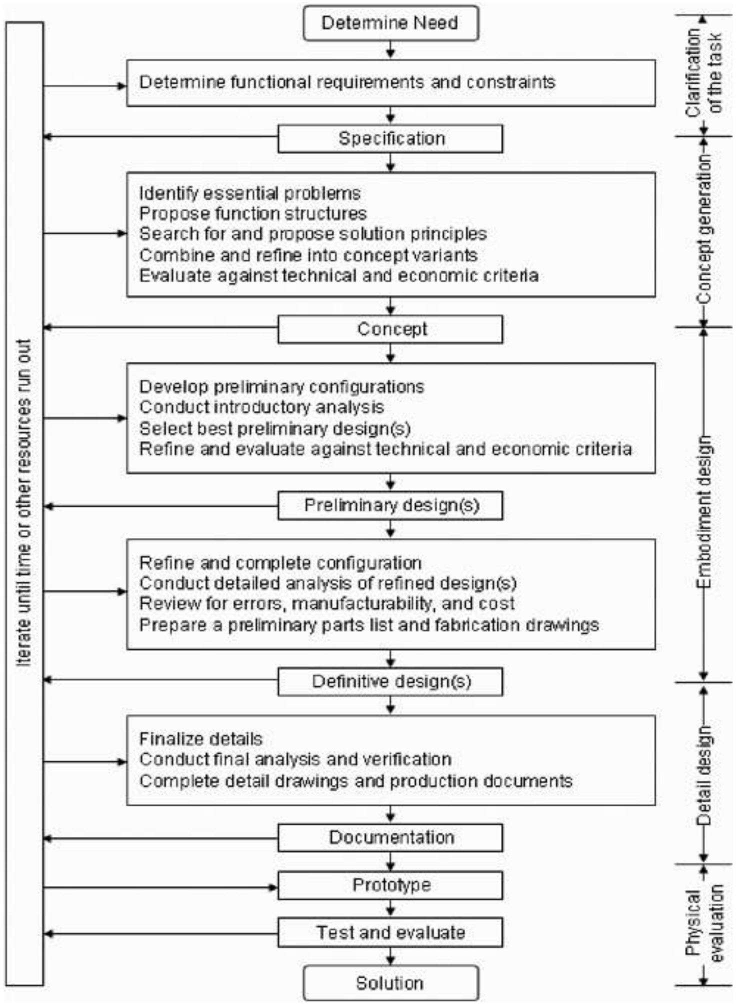
Figure 2.3: New Product Development Process



The product-development process and its identifiable stages are shown in Figure 2.3. Product development includes a number of processes. The steps that follow are given below:

2.4.1 Clarification of the Task

The search for ideas starts from – and is based on - the 'new product' strategy. The ideas that fit in with the strategy have to be identified. The customer needs have to be determined. This should provide pointers towards the functional requirements of the product.

Simultaneously, the organization should be evaluating its resources and time schedules to identify and specify constraints.

Based on this exercise, the general specifications of the product or service are drawn up.

The product idea must demonstrate that it fulfills some consumer need, and that existing products do not already fulfill.

2.4.2 Concept Generation

The specifications are the basis for concept generation. At the concept level, the organization should identify essential problems and propose the function structure of the product or service. This should generate proposals and solution principles that are combined and refined into concept variants.

The concept should be evaluated against technical and economic data. If the results are found satisfactory, the concept has reached the stage for screening.

Screening is a management process. Each idea is analyzed and its risks and potential are scrutinized, both technically and business wise. Those having potential are identified. Most of the ideas are killed or die at the screening level.

The business analysis includes preliminary market analysis, creating alternative concepts for the product, clarifying operational requirements, establishing design criteria and their priorities, and estimating logistic requirements for producing, distributing and maintaining the product in the market.

2.4.3 Embodiment Design

After they have cleared screening, the ideas are developed in their preliminary configuration and an introductory analysis is conducted.

The best preliminary design(s) are:

1. Selected and refined.
2. Evaluated against technical and economic criteria.
3. The preliminary design(s) are refined and the configuration completed.

Detailed analysis is conducted of refined design(s). The design is reviewed for errors, manufacturability and cost. The preliminary design and alternate designs are evaluated according to critical parameters to determine the design support that will be required including analytical testing, experimentation, and physical modeling. Based on the results and trade-offs, the conceptual design is firmed up.

This is followed by:

1. Preparation of preliminary parts list, and
2. Fabrication design for the basic elements of the conceptual design.

This completes the stage of firming up the definitive design of the new product or service.

2.4.4 Detailed Engineering Design

This stage involves engineering a detailed definition of the product, including its components, materials, sizes, shapes, etc. The product design is:

1. Analyzed,
2. Experimented upon, and
3. Data collected to determine if the design meets the design objectives.

Trade-offs are inevitable in the optimal design, since objectives often conflict with each other.

The final design, whether computer generated or compiled manually, includes drawings, specifications and other documentations necessary to form the basis of product and process development.

Did u know? GM and IBM began work in the sixties to develop a system of Computer Aided Design (CAD); today, it has become a commonly used tool.

Originally, CAD was envisaged as a sophisticated drafting system. Today, final analysis and verification is conducted through computer analysis and simulations. Complete and detailed drawings and production documents are then generated.

Prototypes are used to establish the detailed engineering design before the details are finalized. In some cases, especially in defense related products or products whose unit value is extremely high, prototypes are often virtual prototypes.

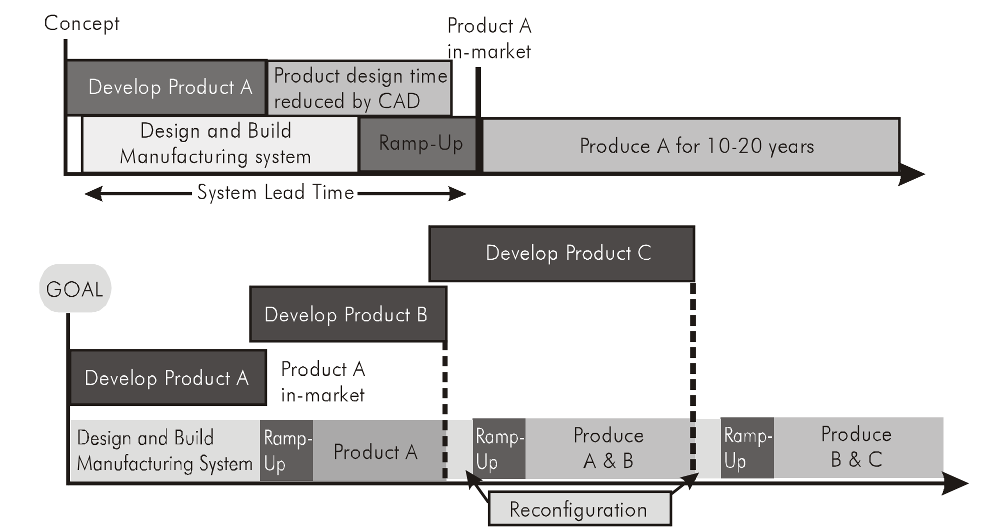
In 1986, I was a member of a team from India that was invited to Brazil to witness the demonstration of an armored vehicle. When we arrived in Sao Paulo, we expected to see the physical testing on the vehicle to demonstrate its capabilities. Instead, we were taken to the main computer center of the firm and the entire sequence of attack and defense, and its consequences were played out on the computer. Sitting in the laboratory, we were able to assess the damage to the vehicle, the parts that had failed and the impact of enemy shells on the body amour.

2.4.5 Physical Evaluation

Concurrently with the development of detailed engineering design, physical evaluation is carried out. This includes:

1. Fabricating a working prototype of the product.
2. Testing and evaluation to confirm that it represents the solution.

Figure 2.4: Product Design Cycle



Very often, the duration of this stage can be reduced if certain tasks are done simultaneously by the organization fully utilizing the benefits of cross-functional thinking. Computer simulations often precede physical evaluation. In currently available CAD systems, the designer can view the part in any orientation, any scale or any cross section. The parts and the product can be seen in the form of three dimensional images, rotated, moved, and the response to different stress patterns seen visually on the computer screen, without building a physical prototype.

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2.4.6 Product and Process Development

Once the detailed engineering is under way, the detailed product design provides the operations team the basis for preparing plans for:

1. Materials acquisitions, and
2. Production.

This involves suppliers also. Suppliers are playing an increasingly important role with the increase in outsourcing.

Operations activities involve:

1. Planning for production and control systems,
2. Computer information systems, and
3. Human resource systems.

Table 2.1: New Product Development Process – Inter-disciplinary Roles

Functional Activities	Phases of Development					
	Embodiment Design		Detailed Design		Product and Process Development	Market Introduction
	Preliminary Design	Definitive Design	Detail Design	Physical Evaluation		
Product Development	Examine technologies; develop product ideas; build models or conduct simulations.	Choose component systems. Identify suppliers; build early system prototypes; define product architecture.	Detailed design of product; build full-scale prototypes conduct prototype testing.	Refine details of product design; Help build second-phase prototypes.	Develop process charts. Evaluate and test pilot units; solve problems.	Evaluate field experience with product.
Marketing	Provide market-based inputs- identify target customers; Define buyer value logic; Specify attributes; investigate product concepts.	Develop estimates of sales and margins; conduct early interaction with customers.	Conduct customer tests of prototypes; participate in prototype evaluation.	Conduct second-phase customer tests; evaluate prototypes; plan marketing rollout; establish distribution plan.	Prepare for market rollout; train sales force and field service personnel; prepare order entry/process system.	Fill distribution channels; sell and promote; interact with key customers.
Manufacturing	Propose and investigate process concepts.	Develop cost estimates; define process architecture; conduct process simulation; validate suppliers.	Design process; design and develop tooling; participate in building full-scale prototypes.	Test and try out tooling and equipment; build second-phase prototypes; install equipment and specify process procedures.	Build pilot units in commercial process; refine process based on pilot experience; train personnel and verify supply channel.	Ramp up plan to volume targets; meet targets for quality, yield and cost.
Finance	Description of financial status.	Initial financial analysis, Return on Investment, Payback period.	Data for cost estimation.	Updating of investment requirements, Capital.	Feasibility of final plans.	Collection of actual cost data.
Information Systems	Classification; organization and tabulation of information at all levels of product development.					
Suppliers		Input to the design of product and process.	Assistance in prototype construction.	Planning for full scale production.		Initiation of production.

2.4.7 Product Introduction

During this stage, the organization needs to monitor customer satisfaction and detect product weaknesses so as provide feedback to the design team.

The product is also monitored for field performance and failure data. This stage is customer support intensive. Support systems might be used to:

1. Educate users on specific applications of the product,
2. Provide warranty and repair service, and
3. Ensure easy availability of replacement parts.

This information is used to monitor, analyze, and modify the product, if necessary.

2.4.8 Concurrent Engineering

The basis for concurrent engineering is the significant overlap among the different phases of product development. This can be seen from Table 2.1. A significant number of companies are already identifying where there is a need to communicate and work together both within the company divisions and with other organizations so as to reduce the time between the finalization of the definitive design and the introduction of the product or service.

In high clock-speed industries, this is critical. Many companies, in this category, use the concurrent engineering approach to speed up the product development process. Teams are constituted that integrate the CE program. There can be three types of teams: (i) program management team, (ii) technical team and (iii) design-build team. Concurrency involves the parallel completion of project phases.

With an integration team ensuring the exchange of information between the teams working on different aspects, it is possible to considerably reduce development times and create high quality product designs that meet customer expectations. Using this technique, some companies boast that they have reduced, by a third or more, the time needed to develop and launch new products. They have injected more customer-related information into the process and to make it flow better.

Example: Some instances of time-savings that have already been achieved are presented below:

1. Chrysler, Ford, and GM have reduced the interval from concept approval to production from 5 to 3 years.
2. Fourteen engineers at the Tank and Automotive Research and Development Center designed a low-silhouette tank prototype in 16 months. By traditional methods, this would have taken 3 years and 55 engineers.
3. Northrop Grumman's CAD systems provided a first-time, error-free physical mockup of many sections of the B2 aircraft in less than one half the time compared to conventional methods.

Numerous examples point that increased and improved communications between all phases will significantly reduce the time from concept to delivery of the product or service to the marketplace.

By improving the quality, timing, and synthesis of information throughout the development cycle, companies can free themselves from prescheduled project time lines and formalized

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process steps and manage their resources and work flows more flexibly. They can keep their product options open longer, act on market information later, and reduce the delays, bottlenecks, rework, and wasted effort inherent in today's assembly-line Product-Development Process.

When the product development cycle is shortened, products can be designed to be more responsive to specific customer requirements. By transforming a sequential process into a more dynamic and information-based concurrent process, companies can quicken the pace of development and improve a product's odds of success.

Task Track the product development process of Tata Docomo and Tata Indigo Manza. Collect as much details as possible.

2.5 Delayed Differentiation

The concept of delayed differentiation, also known as postponement, was first suggested by Alderson in 1950. He suggested that producers should add options or make differentiating changes to the product close to the time of purchase by the end use customer. There are many visible advantages of this concept. Consider the entire supply chain of a product and try to locate the point at which the product has been manufactured or has assumed the final form. How remote is it from the consumer in physical terms or in terms of time? If we give the final form or configure the product close to the consumer, will it really give us any advantage? The answer to the question is intrinsically related with the product type; and, following Fisher's cue, there are reasons to believe that some benefit can be achieved by postponement. This can be achieved by better control of demand information as the final configuration of the product can be manipulated based on more up to date demand information. The manufacturing postponement should allow better management of forecasts and demand information by shortening the manufacturing lead time. This of course seems a very suitable approach for innovative products with short product life cycle and high risk of obsolescence. The classic example of postponement is provided by Benetton, the trade mark Italian apparel manufacturer. Benetton used an innovative manufacturing and supply chain strategy based on postponement to carve out a niche market for itself.

Postponement will not eliminate inventory or surplus material from the system but will shift it up stream. The advantage of postponement is based on two fundamental understandings that aggregate demand of similar products (or same product group) is more predictable compared to demand for individual types, and that it is the finished product which has the short life cycle and high risk of obsolescence. Postponement enables a firm to react more efficiently to demand and is an effective strategy for innovative products. Postponement or delayed differentiation, when taken to the extreme, has resulted in firms adopting a type of 'customization' or 'mass customization'. Manufacturing is postponed until definite demand information is obtained in the way of firm customer orders with specific requirements.

In economic sense, the value of delayed differentiation (also known as postponement) for a monopolist has been extensively studied in the operations literature. It becomes near necessary to analyze the case of (imperfectly) competitive markets with demand uncertainty, wherein the choice of supply chain configuration (i.e., early or delayed differentiation) is endogenous to the competing firms. It requires characterizing firms' choices in equilibrium and analyzing the effects of these choices on quantities sold, profits, consumer surplus, and welfare. We demonstrate that purely strategic considerations not previously identified in the literature play a pivotal role in determining the value of delayed differentiation. In the face of either entry threats or competition, these strategic effects can significantly diminish the value of delayed differentiation.

In fact, under plausible conditions, these effects dominate the traditional risk-pooling benefits associated with delayed differentiation, in which case early differentiation is the dominant strategy for firms, even under cost parity with delayed differentiation. We extend the main model to study the effects of alternate market structures, asymmetric markets, and inventory holdback. Our results – in particular that for a broad range of parameter values, early differentiation is a dominant strategy even under cost parity with delayed differentiation – are robust to these relaxations.

The strategy of achieving competitive superiority through postponement and customization requires, in order to reduce cost and increase manufacturing efficiency, certain design attributes. These are commonality, modularity and standardisation.

2.6 Commonality

Commonality of components used to manufacture similar products is essential to reduce the number of components to be held in stock to cater to all possible combinations of a customer's customization spree. The postponement allows the products to assume their unique characteristic as late as possible.

Example: A cellular phone manufacturer making various models can keep the component inventory level low when almost all components used by all models are common.

The customisation is done by postponing the final assembly of the casing and perhaps some added functional feature till customers indicate their choices for the unique combinations.

Recycling Component Commonality

Recycling refers to the recovering of materials or components for future use. There are several reasons for recycling may be cost considerations, environmental concerns or environmental regulations. Recycling involves the collection of used and discarded materials processing these materials and making them into new products.

Waste recycling has some significant advantages:

1. Leads to less utilization of raw materials.
2. Reduces environmental impacts arising from waste treatment and disposal.
3. Makes the surroundings cleaner and healthier.
4. Saves on landfill space.
5. Saves money.
6. Reduces the amount of energy required to manufacture new products.

2.7 Mass Customization

The concept of mass customisation is built on the concept of postponement. This is the extreme form of postponement as the product is subject to the final configuration as and when the customers' specific order is known. The aim is to provide the customer with custom solutions or, in other words, exactly what he or she wants, but to provide this with the same efficiency achieved in mass production. This is a considerable challenge when we consider how individual choices can vary and what it means to configure products, especially complex products, to each customer desired configuration given that firms are always under pressure of reducing system wide costs through reduction in inventory and the achievement of shorter lead times.

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In spite of this challenge, if mass customisation can be successfully implemented, it is possible to see intuitively that it is the key to increasing value through the provision of unique personal satisfaction; and, of course, this has the potential to generate additional marginal revenue. A second consideration, a more profound and fundamental one, is that the overall effect on inventory related costs can be very positive as production is based on real demand. This is essentially the transformation of the supply chain to a pull system at the customer end. This means that the manufacturing process is completed when definite information regarding customers' preferred configuration or design is available. And, you may have guessed correctly, this information, along with the customers' willingness to wait for the product, are crucial elements, along with the specific characteristics of the product, which would make mass customisation successful.

Example: An example of mass customisation is what is done by Dell computers. Dell's direct supply chain model based on Internet orders and direct shipment to customers in their preferred configuration has made Dell the favoured subject matter of many case studies.

Deciding Product Architecture

The first step in developing a new product strategy is that the organizations should decide their target customers, what they value, and the likely size of the market of their interest. These are key inputs to make product architecture decisions. Product architecture should establish three things:

1. Specify the functional capabilities of the product, its features, and post-sale servicing needs.
2. Specify the capabilities of the product delivery system and post-sale support that the customer expects and determine the ability of the organization to provide for these, and
3. Specify the roles and risks each player within the supply chain will assume.

For businesses that make to stock or assemble to order, the business process that develops a product's architecture must deal with a number of design issues, such as:

1. Can a 'make to stock' product meet the core needs of target customers?
2. Can a 'make to stock' product with a flexible set of optional functional modules satisfy the mix variety demanded by the buyers who want 'assemble to order' products?
3. How can product designers divide the functions of the product among separate modules effectively and how should the modules interface with each other?
4. How much 'technical risk' can the design take?
5. What should be in-house development and what should be contracted out?

These are product design decisions that fall beyond what was called a line of visibility in the service area and a product's customer. But within the firm, they have important effects, not only on product quality, but also on the resources needed to effectively perform the development process.

Good product architecture can help designers develop products capable of providing the firm with a competitive advantage. If being fast to market or fast to product is a strategic goal, then the ability to achieve these ends starts with good product architecture.

Caselet

Customization at BMW

– by a BMW Mini Owner

Driving a BMW-Mini often is seen as the ultimate expression of individualism. People paying the extra premium for a small, but fun car often select a Mini to express their individual lifestyle and to set themselves ahead from the crowd. For me, this always seemed to be a bit a contradiction, as I have seen very few really "cool" people driving a Mini, and at least in Germany, Mini drivers seem to follow a general pattern of belonging to a conservative upper middle-class medium aged segment living in larger cities. (I have, however, to admit that driving a Mini really is fun and a very nice experience). Also, from a mass customization point of view, a Mini has rather limited customization offerings. While the configurator suggests plenty of choice options, they are rather limited, especially with regard to style customization like color combinations between body, roof, and interior. All choices seem to be perfectly balanced to deliver neatly tuned combinations fitting the Mini brand image as seen by its corporate parents. But now, there is ultimate choice. Customers now can freely design the Mini's roof with their very own design. The roof is one of the signature design features of the Mini. It is often selected in a different color than the body. And now you not only can select from 15 or so standard colors, but really design your own.

Source: http://mass-customization.blogs.com

2.8 Standardization of Products and Services

Eli Whitney's use of standard parts enabled his firm to gain a competitive advantage in its bid for an army rifle contract. Henry Ford's assembly lines were made possible by improved manufacturing processes that allowed unskilled workers to quickly attach standard parts to standard cars.

Standard end products enable manufacturers to use 'make to stock' market orientations, thereby decoupling manufacturing decisions from market transactions.

Standardization of products and manufacturing inputs can also help a firm achieve:

1. ***Lower Product Costs:*** Economies of scale occur when product design costs are spread over a large volume. Very often, a standard component in a product provides the same functionality without paying for new engineering work and customization.

   Standardized products often justify investments in more efficient production processes. Higher volume production systems often allow the process to use less skilled employees. However, such standardized parts often result in reduced flexibility.

2. ***Quicker Product Design:*** Standardized product interfaces often reduce product design periods as has been demonstrated in personal computer designs. Manufacturers have benefited by industry standards that define the protocol that must exist between each module.

3. ***Enhanced Product Flexibility Capabilities:*** Standardized features that use standard interfaces permit designers to enhance its offerings without risking incompatibility as long as they stay within the specified parameters.

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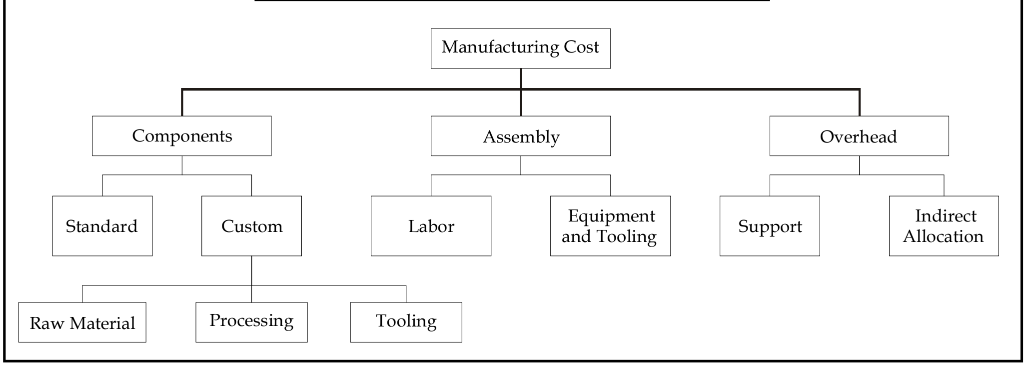
4. ***Delivery:*** Standard products may create economies of scale in transportation. Inventories of standard products can also be placed at sites near customers to facilitate a rapid response to any order, often providing a competitive advantage with time-conscious customers.

5. ***Simplified Value Comparisons:*** Standardized goods help consumers to shop for the best price or product performance. People can easily compare the cost of a 60-watt Philips bulb with a Laxman & Sylvania bulb. It also provides consumer protection as the performance standards are often regulated.

Though the points mentioned below are applicable to all designs, they are especially important in designing products using standard parts. As will be observed from Figure 2.5, standard components require little or no tooling and processing. However, in such products it is essential to ensure and take extra care so that the product:

1. Functions so as to perform as intended;
2. Reliability is ensured so that the product will perform consistently;
3. Is maintainable so that maintenance is economical;
4. Is safe so that it will perform with minimal hazard to the user and the environment; and
5. Production process is simple, so the product can be produced at the intended costs and volumes.

Figure 2.5: Breakup of Manufacturing Costs



2.9 Modular Design

Another way to introduce customized products quickly is to use modular designs. In the fashion world, this is called mix-and-match clothing. In manufacturing, assemble to order systems allow the customer to specify a need and then either the customer or the vendor selects pre-engineered sub-assemblies to meet a customer's need. The product is then either assembled or shipped as a kit to the customer. This is the system that Dell uses. A wider variety of end product options is possible but within certain limits.

Example: The product architecture Maruti Udyog Limited used in launching the Maruti 800, Omni and Gypsy in 1984-85 from a single platform was based on a modular design concept.

Basic modules were integrated to create three different products, with a high degree of commonality of parts. Writing on the product architecture, the General Manager of MUL in his note referred to earlier wrote,

"*It is possible for us to find a product which can, with necessary engineering inputs, with a high degree of parts commonality, cater to the demands of the three demand segments identified earlier. This vehicle, I am*

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defining as a Universal Vehicle… the logic of this type of conversion of a sedan to the Universal Vehicle is the use of mass production technology in the manufacture of aggregates, so as to minimize the cost of built-up products….

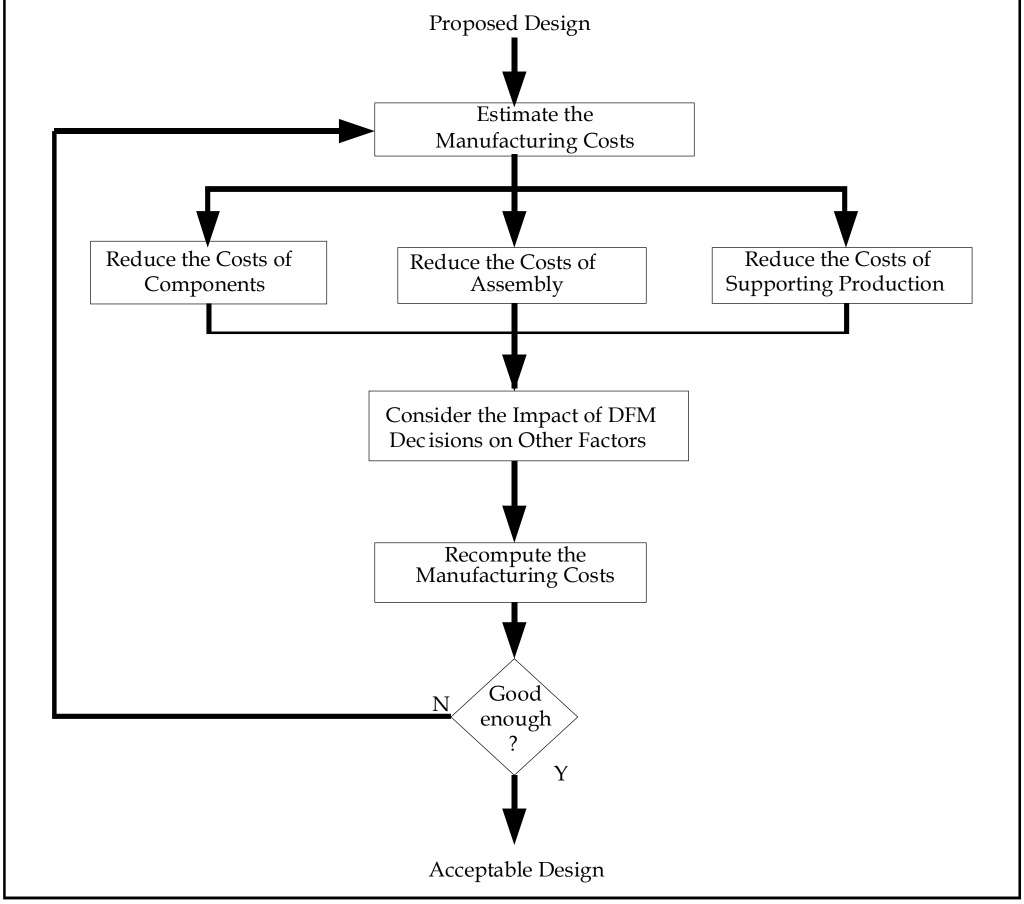
If the objectives for 1987-88, is laid down to capture 50 per cent of the car, jeep and light commercial vehicle market and defence requirements, the domestic sales will be of the order of 70,500 units, including spare parts requirements. With a focus on this type of volume, the project becomes economically viable."

The key to successful product development is to know what features or parts of the end product need to be customized to meet the expectations of the target customers.

2.10 Design for Manufacturability (DFM)

1. DFM is the process of designing a product for efficient production while maintaining the highest level of quality.
2. It is intended to avoid more complex and expensive product designs to simplify assembly operations.

Figure 2.6: The DFM Process



The flowchart for the DFM process is given in Figure 2.6. Some guidelines to determine whether the design is good enough are given below:

1. Minimize the number of parts
2. Develop a modular design

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3. Design parts for multi-use
4. Avoid separate fasteners
5. Eliminate adjustments
6. Design for top-down assembly
7. Design for minimum handling
8. Avoid tools
9. Minimize sub-assemblies
10. Use standard parts when possible
11. Simplify operations
12. Design for efficient and adequate testing
13. Use repeatable and understood processes
14. Analyze failures
15. Rigorously assess value

DFM is a team-based approach that involves everyone associated with the development process.

Example: The US Navy's modeling and simulation processes for the Virginia-class submarine reduced the standard parts list from 95,000 items for the earlier Seawolf-class submarine, to 16,000 items.

DFX - Design for 'X': DFX is a special case of DFM, where a certain area, say 'X' is selected for attention. Improvements in 'X' are proposed after detailed analysis of the process by a team of cross-functional experts. The performance measures are established and items are identified that will simplify the process and at the same time provide value to the customer.

Example: Escorts Ltd., a company that was making heating elements for electrical kettles. The holder that screwed on the element to the kettle was made as a casting. The casting had to be pre-machined, sized, cut and turned before it was ready for threading.

The technical requirements were not critical, as the function of the part was to protect the consumer from contact with the electrical contacts and guide the external socket to the corresponding part of the heating element. Standard tubes were found that met the dimensional requirements for the component. This greatly simplified the process, avoided a number of operations, reduced the number of parts, and also reduced costs.

Task Enlist a few companies that produce both customized and standardised products. Name their products in each category.

2.11 Service Design

Services can be classified on the basis of the degree of contact with the customer. The extent of customer contact can be defined as the percentage of time the customer must be in the system relative to the time it takes to perform the customer service.

Low Degree of Customer Contact

Services, with a low degree of customer contact, involve the same stages as the design of manufactured products. The service system product development process is comparable to manufacturing shown in Figure 2.6.

However, services often do not require a physical component, such as prototype building, etc., and the process technology sometimes involves different issues and considerations because the conversion process takes place before the client or customer.

High Degree of Customer Contact

Services with a high degree of customer contact are difficult to control as the customer can affect the time of demand, the exact nature of the service, and the quality or the perceived quality of the service. These types of services often require a high degree of personalization and speed of delivery.

Services normally require a much higher levels of capacity relative to demand and also require greater flexibility. There can be tremendous diversity of customer influence and hence greater system variability.

2.12 Differences between Product Design and Service Design

The difference between manufactured goods and services serves as the basis for the difference in their designs. Manufactured goods differ from services in three ways:

1. The first is that a good can be inventoried, thereby giving system designers additional degrees of freedom.
2. The second difference relates to risk. More so than for services, the design of manufactured products and their supporting delivery systems requires substantial up-front financial commitments.
3. The third difference is that the product innovation process for goods are often supply chain-wide dependent.

Example: For Intel to develop next-generation micro-processor chips, it requires co-ordinate its efforts with software players, application developers and the makers of chip manufacturing equipment.

Notes **Technological Capabilities and Product Development**

Technological Capability	Definition	Description
Reverse Engineering	Ability to imitate an existing product.	For example, Sharp Corp. imported a crystal radio set from USA in 1925; reverse engineered it and made Japan's first radio, the Sharp – Dyne.
Product Innovation	Development of a new product.	Innovations that lead to improvements of existing products or development of new products. The innovations could be incremental, architectural, modular or radical.

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Process Innovation	Improvements in process for product manufacturing.	Improvements in the manufacturing process, integration of steps in the manufacturing process leading to reductions in cycle time or reductions in the number of process types, improving the manufacturing process yields.
Application Innovation	Utilisation of an existing idea or concept for a new application, or a new design, method or measurement technique.	Incorporation of a new idea, design method or testing concept to improve, sometimes dramatically, existing products and processes. For example, the development of Nylon into material for use as tyre cords.
System Innovations	Innovations involving integration of sub-systems and several innovations.	Introduction of new systems through linking or integration of a variety and sub-systems, and involving product, process and application innovations. For example, application of fuzzy logic to improve continuous cold rolling mills in steel manufacturing.
Core Competence Leveraging Innovations	Ability to leverage and enhance innovative activity from its areas of core competence: 1. Expansion of innovation in the different phases of innovation. 2. Extension of core competence horizontally into a new field. 3. Fusing core competence in different areas.	Firm's capability to innovate in all phases of innovation process, such as design, engineering, testing and manufacturing, forms its core competence. 1. An example is Hitachi's ability to design and produce 1MB DRAM in 1985, extended to 16 MB by 1990. 2. For example, Hitachi's developments of the world's largest Ga-As single crystal and then using this technology in satellite broadcasting. 3. For example, thermostatic ceramic textiles are a fusion of core competencies in textiles, space and chemical technologies.

2.13 Reliability

Reliability serves as a measure of quality of the product and service design. The quality associated with a product often increases with the dependability of the product customer experience.

Example: Patients expect the hospitals to have competent staff. People expect mobile networks to be congestion free etc.

One of the emerging disciplines is Design for Reliability (DFR) that refers to the process of designing reliability into products. This process encompasses several tools and practices and describes the order of their deployment that an organization needs to have in place in order to drive reliability into their products. Typically, the first step in the DFR process is to set the system's reliability requirements. Reliability must be "designed in" to the system. During system design, the top-level reliability requirements are then allocated to subsystems by design engineers and reliability engineers working together.

Reliability design begins with the development of a model. Reliability models use block diagrams and fault trees to provide a graphical means of evaluating the relationships between different parts of the system. These models incorporate predictions based on parts-count failure rates taken from historical data. While the predictions are often not accurate in an absolute sense, they are valuable to assess relative differences in design alternatives.

One of the most important design techniques is redundancy. This means that if one part of the system fails, there is an alternate success path, such as a backup system.

Example: An automobile brake light might use two light bulbs. If one bulb fails, the brake light still operates using the other bulb.

Redundancy significantly increases system reliability, and is often the only viable means of doing so. However, redundancy is difficult and expensive, and is therefore limited to critical parts of the system. Another design technique, physics of failure, relies on understanding the physical processes of stress, strength and failure at a very detailed level. Then the material or component can be re-designed to reduce the probability of failure. Another common design technique is component de-rating: Selecting components whose tolerance significantly exceeds the expected stress, as using a heavier gauge wire that exceeds the normal specification for the expected electrical current.

Improving Reliability

There are two suggested approaches for improving the reliability of a system: fault avoidance and fault tolerance. Fault avoidance is achieved by using high-quality and high-reliability components and is usually less expensive than fault tolerance. Fault tolerance, on the other hand, is achieved by redundancy. Redundancy can result in increased design complexity and increased costs through additional weight, space, etc.

Before deciding whether to improve the reliability of a system by fault tolerance or fault avoidance, a reliability assessment for each component in the system should be made. Once the reliability values for the components have been quantified, an analysis can be performed in order to determine if that system's reliability goal will be met. If it becomes apparent that the system's reliability will not be adequate to meet the desired goal at the specified mission duration, steps can be taken to determine the best way to improve the system's reliability so that it will reach the desired target.

We need to answer some basic questions before getting down to improving the system's reliability. How much does each component need to be improved for the system to meet its goal? How feasible is it to improve the reliability of each component? Would it actually be more efficient to slightly raise the reliability of two or three components rather than radically improving only one?

In order to answer these questions, costs must be analyzed. Cost does not necessarily have to be in monetary terms. It could be described in terms of non-monetary resources, such as time. By associating cost values to the reliabilities of the system's components, one can find an optimum design that will provide the required reliability at a minimum cost. There is always a cost associated with changing a design due to change of vendors, use of higher-quality materials, retooling costs, administrative fees, etc. The cost as a function of the reliability for each component must be quantified before attempting to improve the reliability. Otherwise, the design changes may result in a system that is needlessly expensive or over-designed. Developing the "cost of reliability" relationship will give the engineer an understanding of which components to improve and how to best concentrate the effort and allocate resources in doing so. The first step will be to obtain a relationship between the cost of improvement and reliability.

The preferred approach would be to formulate the cost function from actual cost data. This can be done from past experience. If a reliability growth program is in place, the costs associated with each stage of improvement can also be quantified. Defining the different costs associated with different vendors or different component models is also useful in formulating a model of component cost as a function of reliability.

For the purposes of reliability optimization, we also need to define a limiting reliability that a component will approach, but not reach. The costs near the maximum achievable reliability are

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very high and the actual value for the maximum reliability is usually dictated by technological or financial constraints. In deciding on a value to use for the maximum achievable reliability, the current state of the art of the component in question and other similar factors will have to be considered. In the end, a realistic estimation based on engineering judgment and experience will be necessary to assign a value to this input. One must note that the time associated with this maximum achievable reliability is the same as that of the overall system reliability goal. Almost any component can achieve a very high reliability value, provided the mission time is short enough.

2.14 Computer-aided Design (CAD)

Computer-aided Design (CAD), also known as Computer-aided Drafting, is the use of computer software and systems to design and create 2D and 3D virtual models of goods and products for the purposes of testing. It is also sometimes referred to as computer assisted drafting.

2.14.1 Advantages of CAD

In the field of product development there are often immense costs associated with the testing of new products. Every new product must undergo at least a small measure of physical testing – not only to ensure that it meets minimum safety standards but also to ensure that it will successfully operate under the range of conditions to which it can expect to be exposed.

Example: The wing of an airplane must undergo stress tests to ensure that it will retain its integrity even under the most grueling weather and turbulence conditions before it is approved for use.

Unfortunately, this testing can be ruinously time-consuming and expensive. If an aeronautical company has to physically build dozens of wings in the course of testing a new design then the final cost and time scale of the project can be far higher than projected. Fortunately, there is no need to physically test all of these designs. Instead, developers can run virtual stress tests using computer-aided design, substituting a wind tunnel for a CAD application that can simulate the same conditions.

The benefits of virtual simulations are obvious. In addition to a reduction in the cost of product development and the time required to run tests there is also the advantage that conceptual designs can be modified instantly as the tests progress.

Perhaps one of the best examples of this versatility can be seen in the design of the airplane wing. The science of aerodynamics is complex, and it is often the case that certain wing shapes can create unexpected turbulence under certain conditions. When this occurs during physical testing it can be a challenge to discover the problem and make alterations. When running virtual tests using CAD, however, alterations to the design can be made quickly and easily, so new designs can be tested and retested until the problem is resolved.

2.14.2 Business Applications for CAD

Idea Generation

With the limiting factor of prototype manufacture removed, CAD allows the process of idea generation to become much more flexible. Enterprises can afford to be more open to new ideas and suggestions than in the past – from both employees and potential customers. Suggestions for new products can be quickly tested at a much lower cost than in the past.

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Augmentation

CAD opens up the possibility to make slight improvements on new product designs instantly. While this can be of great benefit in the design of a new product it can also be extremely useful for investigating possible improvements to existing products – or even reverse engineering and augmenting the products of competitors.

Market Testing

Through designing new products using CAD it becomes possible to begin the process of market testing much earlier than in the past. Focus groups can be presented with virtual mock-ups of new products more quickly than would be possible with physical prototypes, and alterations can be made based on their feedback almost instantly. Since modifications can be made simply by entering new data into the CAD software, updated virtual mock-ups can be presented to the same audience for further feedback during the same session.

Case Study

Designing Maruti 800

This note was given by the General Manager of Maruti Udyog Ltd. to its Vice Chairman, as a basis for selection of the product that needed to be selected for manufacture. The nationalization of Maruti in 1981 created an opportunity for the government to revamp the Automotive Industry in the country. The challenge of revamping the Automotive Industry could be met if Maruti could manufacture quality products at competitive prices. The most important decision before the new company was the selection of the right product and product mix, as many projects falter due to the choice of inappropriate technology or product mix at the start of the project.

The positioning of Maruti Udyog was reflected in the key words: modern and contemporary; lower operating costs; commercially viable products; modern process technology. Its objectives were:

1. To offer vehicles which are modern and contemporary in design so as to raise the level of automotive technology within the country;
2. To manufacture these vehicles with operating costs comparable to world standards and lower than that of existing vehicles, for improved consumer values;
3. To generate economies of scale and thereby create commercially viable products, introducing modern process technology in the engineering industry.

The price difference between a passenger car and scooter/motor-cycle was over ₹ 60,000 per unit. There was an extremely large market of scooter/motor-cycle owners, who could be developed into car owners. No manufacturer had been able to service this market. In case, this market could be serviced, it would create a totally new demand segment and would be independent of conventional demand for passenger cars, which had been stationary for quite some time. The new demand would generate primarily from the high-income group owners of two wheelers.

To capitalize on this market segment, the traditional concept of cars would need to be abandoned and the approach to the passenger car would have to be unique and revolutionary. I have looked at compacts and noticed the following points:

1. Have superior performance characteristics, compared to existing cars manufactured in India.

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2. Around 15-20 per cent more fuel-efficient than the medium cars of the same manufacturer.
3. Around 25 per cent less expensive than the medium car of the same manufacturer.

We need to look at subcompacts and not compacts. Sub-compacts have further advantages in terms of fuel efficiency and price over the compacts. Compacts have traditionally been manufactured by high production volume technology. The manufacturing cost of this type of vehicle is highly dependent upon the volumes that can in order to reach BEP and start generating surplus be generated. Sub-compacts do not need to be manufactured in very large numbers; the sub-compact is, therefore, less sensitive to volume requirements than other categories of passenger cars.

If volume is not the predominant criteria in the manufacture of sub-compacts, export of these vehicles is not a very important requirement. An inexpensive, fuel-efficient and modern car catering to the needs of the middle and upper-middle class can, therefore, be designed with specifications relating to Indian needs.

It is possible for Maruti to manufacture a small car more closely related to a sub-compact rather than a compact, which will meet the aspirations of the general public. Specifications for such a car need to be drawn up in detail so as to incorporate the desirable characteristics that one is looking for. The buying price should be less than ₹ 40,000 for a consumer. Keeping in view these objectives, draft specifications have been described in the Box below:

Box 1: General Specifications of a Suitable Sub-compact Vehicle

General description

1. Five seater, four door/five door car with front wheel drive;
2. Kerb weight less than 650 kg. ;
3. Carrying capacity above 380 kg. ;
4. Independent suspension on all wheels;
5. Drag coeff. Less than 0.40.

Performance

1.	Specific fuel consumption	180-200 gms/hp/hr.
2.	Max. torque of engine (min.)	5.0 kgm.
3.	Compression ratio (min.)	9.1 with 83 octane fuel.
4.	Power weight ratios (min.)	
5.	Laden	28 kg. /h.p.
6.	Unladen	20 kg. /h.p.
7.	Max. speed	10 kmph.
8.	Acceleration standing ¼ mile (secs)	22 secs.
9.	Fuel efficiency	4.5L x 100 approx. at 90km/h with 83 octane.

Desirable Options

1. Diesel engine, transversely mounted
2. Electronic Engine control.

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Though prima facie the cost objectives seem to be extremely ambitious, it is my belief that it will be possible to manufacture such a vehicle at the prices that have been mentioned based on a sympathetic Government Tariff structure.

Box 2: Projective Computation of Manufacturing Costs

Assumptions

1. There will be a logical relationship between the manufacturing cost of existing cost of existing Cars and the proposed Car.
2. Comparison is made on the basis of Ambassador Car inputs.
3. Selling and marketing costs assumed at 10% of the selling price.
4. Overheads assumed at 15% for Ambassador.
5. Weight of Maruti Car assumed at 650 kg.

Maruti Proposal

Assumed material costs (2)	:	30% above Ambassador
Cost per kg.	:	₹ 29.47
Material cost	:	₹ 19,150 approx.
Overheads - 30% (3)	:	₹ 9,500
Selling costs	:	₹ 3,200
Selling price (1)	:	₹ 31,850

1. Selling price is the ex-factory value of the product. All government taxes and levies are extra.
2. Higher overheads have been assumed to cover higher depreciation, amortization and interest costs.

Box 2 gives an analysis of how this price has been theoretically arrived at. It may be noted that sub-compacts are also sold at similar prices.

The fact that Maruti got its product selection right has provided it a competitive advantage that has been retained by the company for the last two decades. In spite of the entry of international companies into the automobile sector, no manufacturer has been able to break the stranglehold of the Maruti 800.

According to Arindam Bhattacharya of A.T. Kearney, "The Maruti 800 is a great product. No other car in the world can match its functionality and price... There is need for such a car, which competes not with other cars but two wheelers."

Questions

1. Why, do you think, Maruti 800 was such a success?
2. Discuss the positioning of the Maruti 800 car.

2.15 Summary

- Customer satisfaction, functionality of the product, cost considerations, ease of production and maintenance are some of the major considerations while designing any product or service.

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- The legal issues involved in designing products and services are- patents, trademarks, copyrights, product liability and Uniform Commercial Code whereas the Environment Protection Act governs the issues relating the environment.
- The product lifecycle model is a simple representation of the cumulative impact of changes in the business environment on the life of a manufactured product.
- Statistical regularities show that the product lifecycle can be used to forecast the way the product attributes, demand, production and competition will change as the product matures.
- A mature industry can continue indefinitely. Competitors with more abundant resources, cheaper labour or subsidized capital can obtain a competitive advantage.
- The length and pattern of the Product Lifecycle can vary significantly. There is no reason to believe that all products inevitably pass through all four stages, e.g., fad items, consumer resistance, and introduction of superior new product.
- Without products, there would be no customers. Without customers, there would be no revenue. Developing a new product is a major activity.
- Organizations are more concerned about being the first to develop an idea or design a product so that they can protect their markets. Being able to design, develop, and introduce a new product quickly gives a firm 'fast to market' capabilities.
- The basis for concurrent engineering is the significant overlap among the different phases of product development.
- Delayed differentiation concept suggests that producers should add options or make differentiating changes to the product close to the time of purchase by the end use customer.
- Commonality of components used to manufacture similar products is essential to reduce the number of components to be held in stock to cater to all possible combinations of a customer's customization spree.
- The concept of mass customisation is built on the concept of postponement. This is the extreme form of postponement as the product is subject to the final configuration as and when the customers' specific order is known.
- Standard end products enable manufacturers to use 'make to stock' market orientations, thereby decoupling manufacturing decisions from market transactions.
- DFM is the process of designing a product for efficient production while maintaining the highest level of quality.
- Services can be classified on the basis of the degree of contact with the customer. The extent of customer contact can be defined as the percentage of time the customer must be in the system relative to the time it takes to perform the customer service.
- Reliability serves as a measure of quality of the product and service design. The quality associated with a product often increases with the dependability of the product customer experience.
- There are two suggested approaches for improving the reliability of a system: fault avoidance and fault tolerance. Fault avoidance is achieved by using high-quality and high-reliability components and is usually less expensive than fault tolerance.
- When running virtual tests using CAD, alterations to the design can be made quickly and easily, so new designs can be tested and retested until the problem is resolved.

2.16 Keywords

CAD: Use of computer software to design and create 2D and 3D virtual models of goods and products for the purposes of testing.

Commonality: Used to manufacture similar products.

Concurrent Engineering: Involves the parallel completion of product phases based on overlap among different phases of business development.

Customization: Product is subject to the final configuration as and when the customers' specific order is known.

Delayed Differentiation: Adding differentiating changes to the product close to the time of purchase by the end use customer.

Design for Manufacturability: Process of designing a product for efficient production maintaining highest level of quality.

Design for Reliability: It refers to the process of designing reliability into products.

Modular Design: System that allows pre-engineered sub-assemblies to meet a customer's need.

Product Architecture: Establishes functional capabilities of the product, its features and post sale servicing needs.

Product Lifecycle: Simple representation of impact of changes in business environment on products.

Recycling: Recovering of materials or components for future use.

Reliability: It serves as a measure of quality of the product and service design.

Standardization: Maintaining a standard quality and features for all designs.

Technology Lifecycle: It is used to forecast the way demand, production and competition will change as product matures.

2.17 Self Assessment

State whether the following statements are true or false:

1. A particular product can be designed in a specific way just because the assembly line is fast and reliable.
2. A particular ingredient design of any delicacy of a particular restaurant is protected under the patent law.
3. There is a severe competition, in fact most severe during the growth stage of the product or service.
4. Honda's I-VTec technology is a mature technology.
5. CAD was designed by GM and Microsoft.
6. Use of Benetton as classic example for postponement emerges out because it used to dye its apparels after converting it from yarn to cloth.
7. Maruti Suzuki also offers customized products to the customers of its specific few brands of cars.
8. While discussing Design for Manufacturing, less attention is given to quality.

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9. Services with high degree of customer contact like banking requires high quality designing.
10. Fault tolerance is any day better way of improving reliability than fault avoidance.

Fill in the blanks:

11. The governing authority for paper transactions in product design was created in……………
12. Automobile parts are product………………while Bosch is a product…………….
13. Many ideas that might lead to the development of a new product or service are mostly left out at the………………..stage.
14. …………………is adopted by the firms to lower the costs of manufacturing while maintaining quality.
15. In manufacturing world, computer aided drafting is better known as………………..

2.18 Review Questions

1. "Product decisions often make or break companies". Discuss.
2. Suppose you are the product manager of a company engaged in production of motorbikes. You are faced with a situation wherein you have to choose between designs, one which can give maximum value to consumers or one which is cost-effective. Which one will you choose and why?
3. How can the service designers be kept under check? Name a few companies that were involved in any legal dispute over product design.
4. Explain the concept of product lifecycle. Which is better from operations point of view– product lifecycle or technology cycle? Why?
5. Does the concept of product lifecycle always hold good? Discuss the situations where it is not valid.
6. "Without products, there would be no customers. Without customers, there would be no revenue." What implications does this have related to design?
7. Critically analyse the concept of delayed differentiation.
8. Why, do you think, concurrent engineering is more critical in high clock-speed industries?
9. Discuss the concepts of commonality and recycling component commonality.
10. "Mass customization is a challenge but very useful if implemented successfully". Validate the statement.
11. Explain the role of product architecture in gaining competitive advantage.
12. What is mix match clothing? Why it has become popular?
13. What is the difference between DFM and DFR? Explain their importance in operations management.
14. How is reliability of product design related to quality? What is redundancy?
15. Write short notes on CAD and concurrent engineering.
16. "We will offer a small passenger car priced at ₹ 1 lac to our customers by the end of this decade" says, Mr. Ratan Tata. Relate this statement to the product development strategy of Maruti Udyog Ltd. and explain your recommendations.

This question requires students to demonstrate an understanding of the competing requirements of the market and how the market determines the requirements for new product design. How do you identify such challenges?

Indicative Content

Maruti Udyog built a competitive advantage that it has retained for over 25 years by creating a product that met consumer requirements and yet could be profitably priced between the price of a two wheeler and a 4-wheeler. We are now seeing the full circle taking place; with the introduction of the Swift, Maruti is moving into the higher priced segment and TELCO is attempting to replace it in the low cost segment.

This fact has to be analyzed in terms of the different options available to TELCO to bring in a product with the defined characteristics. The students have to develop a product development plan and focus on issues and problems that this plan may encounter. They have to suggest remedies to offset the problems and bring the project to fruition.

The role of technology in determining both the nature of challenges could usefully be mentioned. This could lead to some key activities like research and development and favourable innovative conditions. Illustration by reference to examples from other companies with which the students are familiar is important.

17. How do you classify products? What are the factors that provide value to the product? Explain.
18. Why is the area of product development so important to the future of the company? Can you categorize industries on the basis of the pressures they feel due to product development? Explain.
19. What are the steps and stages of product development? Is it possible to reduce the time and the number of stages and come out with a new product and service? Give details of procedures and techniques.
20. Differentiate between fixed costs and variable costs and explain how they help in determining the breakeven point.
21. Explain the following in relation to new product development:
    (a) Standardization
    (b) Simplification
    (c) Speed to Market
    (d) Activity Based Costing
    (e) Value Engineering
    (f) Modular Design
22. How does Design for Manufacturability (DFM) work? How are DFM and Value Engineering different? Explain with examples.

    Work out the design of any simple object of your choice using the principles of DFM?
23. How do product development strategies relate to the other organizational strategies (i.e., competitive and functional)? What is the difference between single and multi-business organizations? Provide examples.

    The following is the outline of a debate focusing upon one of the key methods of corporate development, strategic alliances, and how their use might be affected by an organization's view of the different approaches to corporate (multi-business level) strategy.

Notes

Indicative Content

Students need to provide a description of the different possible types of strategic alliance—from joint ventures to network organizations to informal agreements. Providing some context to the growing number of alliances in many industries would be helpful.

The debate over the use of alliances, in contrast to other methods of corporate development, implied by the statement, requires the student to outline the three broad styles/logics of corporate strategy discussed in the lectures: the Financial Control/Portfolio approach; the Strategic Control/Linkages approach; and the Strategic Planning/Core Competencies approach. The key parameters of management style (in terms of planning/control influence) and differing logics of synergy should be outlined.

Whichever course is taken, the student then needs to draw out the implications of the approach for alliances. For example, a company relying on a financial control/portfolio approach will be unlikely to consider a strategic alliance at a corporate level, although a particular business unit might initiate such an approach. In contrast, a company which stresses core competencies and the need for learning is likely to consider alliances a key part of the toolkit of corporate management. The other methods of corporate development (internal methods and acquisitions and mergers) could be mentioned, as could the different directions of development.

Students need to demonstrate an understanding of the topic in general, but also evaluate the statement made by engaging in the argument before coming to a clear conclusion, whether for or against.

Answers: Self Assessment

1. True
2. False
3. False
4. False
5. False
6. True
7. True
8. False
9. True
10. False
11. 1952
12. Form, Brand
13. Screening
14. DFM
15. CAD

2.19 Further Readings

Books

Chase, Richard B., and Eric L. Prentis, *Operations Management: A Field Rediscovered,* Journal of Management, 13, no. 2 (October 1987): 351: 366

Hayes, Robert H., *Towards a 'New Architecture' for ROM,* Production and Operations Management, 9, no. 2 (Summer 2000) 105-110.

Schonberger, Richard J., *World Class Manufacturing: The Next Decade,* New York: The Free Press, 1996.

Notes

Online links

www.netmba.com/marketing/product/lifecycle

www.nngroup.com/reports/life_cycle_of_tech.html

http://www.marcbowles.com/courses/adv_dip/module4/module10/m10three.htm

http://www.weibull.com/SystemRelWeb/component_reliability_importance.htm

http://www.scribd.com/doc/12630984/MBA-IInd-SEM-POM-Unit-12-Product-Design-Manufacturing-Technology

Notes

Unit 3: Capacity Planning

CONTENTS

Objectives

After studying this unit, you will be able to:

- Explain measuring capacity
- Understand determining capacity requirements
- Discuss calculating processing requirements
- Describe make or buy decisions
- Explain developing capacity alternatives
- State challenges of planning service capacity
- Describe CVP analysis

Introduction

Product design, capacity and process selection have a direct relationship. Product design determines the value provided to the customer; the value determines the market size; the market size determines the volumes and therefore the capacity; and capacity leads to the process.

Capacity planning should be solely based on the principle of maximizing the value delivered to the customer. This reflects in minimizing costs of producing products and services, providing them in a timely manner, and ensuring that the products provide the highest level of quality.

Capacity planning has become a strategic tool in the operations function. It guides our choices on capacity, locations, and layout for the long-term. It also helps in managing supply and demand, and these choices in turn, affect the ways a firm uses its resources and facilities in the short-term.

3.1 Defining Capacity

It is necessary to recognize the difference between theoretical capacity and normal capacity. Theoretical capacity is what can be achieved under ideal conditions for a short period of time. Under these conditions, there are no equipment breakdowns, maintenance requirements, set up times, bottlenecks, or worker errors.

However, to an operations manager, this description of Capacity may be quite meaningless. As no equipment operates around the clock, seven days a week, there have to be allowances made for maintenance, breakdowns, set up times, errors, etc. Capacity, therefore, is the quantity of output, which is estimated on the basis of normal conditions.

Normal Capacity describes the maximum producible output when plants and equipment are operated for an average period of time to produce a normal mix of output. Due to defining capacity in this manner, it is not unusual for a facility to operate at more than 100 per cent capacity. Capacity is mathematically expressed as:

Capacity = (Maximum production rate/Hour) x (Number of hours worked/Period);

where, Production Rate = Number of units produced/Amount of time

The firm's capacity to produce, whether measured as output or input, depends on the number or type of equipment it has – the intensity with which this equipment is used – the production efficiency, the nature and extent of the supply chain; the product mix to be produced, the demand levels, and distribution capabilities.

Example: Capacity can be changed by changing the number of working hours, production rate, or product mix.

Though, the normal capacity can be measured in the manner described above, it is often difficult to measure operational capacity. There are day-to-day variations, job changes, product mix changes, absenteeism, equipment breakdown, facility downtime, etc. Due to these variations, the capacity of a facility can rarely be measured in precise terms, so measurements must be interpreted with care.

Effective Capacity (utilization): It is found that an organization can operate more efficiently when its resources are not stretched beyond a limit. Effective Capacity is the Capacity, which a firm can expect to achieve, given it's product mix, methods of scheduling, maintenance, and standards of quality.

Notes

Efficiency is a measure of actual output over Effective Capacity and is expressed as a percentage of the Effective Capacity.

The Rated Capacity is a measure of the maximum usable capacity of a particular facility.

Rated capacity = (Capacity) × (Utilization) × (Efficiency)

Example: One facility has an efficiency of 90 per cent, and the utilization is 80 per cent. Three process lines are used to produce the products. The lines operate 6 days a week and three 8-hour shifts per day. Each line was designed to process 100 standard products per hour. The rated capacity is:

$$\begin{aligned}\text{Rated Capacity} &= (\text{Capacity}) \times (\text{Utilization}) \times (\text{Efficiency})\\ &= (100) \times (3) \times (144) \times (0.8) \times (0.9)\\ &= 31{,}104 \text{ products/week.}\end{aligned}$$

The matter of product mix is important, especially while planning for future activities. Top management often finds it desirable to express addition to new capacity in terms of money value of sales. Details regarding product mix breakdown, type and number of machines needed, etc., which are vital to achieve the desired increase in capacity, are left to the concerned engineers. Thus, the definition of unit of output is closely linked with the product mix, and therefore poses a difficult problem as regards capacity measurement.

Time poses another problem. Capacity is often defined as the quantity of output in a given time. However, some manufacturing processes require continuous operation. Thus, a thermal power generation unit must either operate continuously or not at all, as otherwise the boilers cool down. So, the capacity of a thermal power generation unit is the total amount of electricity it can produce by operating 24 × 7. Most factory operations are not, however, like this, since they operate on a shift basis and hence for a specified period. However, these capacities are measured by the output per shift.

Individual Machine Capacity

No matter how broadly we may define capacity, in the final analysis, in manufacturing, it has to come down to capacity of individual machines. The plant usually comprises of a set of work centers for performing various operations that are involved in the process of transformation. Each work center consists of machines of a given type like lathes, milling machines, etc. Once the capacity of an individual machine is determined, it is an easy matter to assess the capacity of the work center.

However, this is often not so simple, since the individual machine capacity itself will depend upon a number of factors such as machine utilization ratio, number and type of operations performed on the machine, the individual operation times as well as machine setup time, etc. Nevertheless, estimation of individual machine capacity can often serve as an aid in assessing the capacity of the work center. Knowledge of the individual work center capacity can then enable us to assess the entire plant capacity.

3.2 Measuring Capacity

A dictionary definition of Capacity is the ability to hold, receive, store, or accommodate. Capacity is also defined as the maximum output of a system in a given period under ideal conditions.

To estimate Capacity, you must first select a yardstick to measure it. The first major task in Capacity Measurement is to define the unit of output. In some cases, the choice is obvious.

Example: RIL set up capacity to manufacture 250,000 MT of polypropylene and 160,000 MT of polyethylene at its Hazira plant. This measures the output of the end products. Another example is megawatt-hours of electricity for a power generation utility.

Finding a yardstick to estimate capacity is more difficult in many service industries where there is no uniform product on which the measurement can be based, e.g., airlines, hospitals, restaurants, etc. However, measures can be devised to assess capacity. For example, an airline can use seat-miles as a measure of capacity. A hospital can measure capacity as beds-days each year. In a restaurant, this might be the number of customers that can be handled per day.

In a process-focused facility, Capacity is often determined by some measure of size, such as the number of beds in a hospital, seating capacity in a restaurant, etc.

In a repetitive process, the number of units assembled per shift, such as number of refrigerators, may be the criterion for Capacity.

And in a product-focused facility, such as TISCO, tones of steel processed per shift may be the measure of capacity.

Whatever the measure, the Capacity decision is critical to the management of an organization because everything from cost to customer service is measured on the basis of the Capacity of the process, once the Capacity is determined.

In general, Capacity can be expressed in one of two ways:

1. Output measures or
2. Input measures.

1. ***Output measures*** are the usual choice for high-volume processes.

Example: Maruti was set up to manufacture 100,000 passenger cars per year.

This type of capacity measurement needs to be taken with some caution. The Maruti plant produces three types of vehicles on a single platform. As the man-hours required to produce the different models are not identical, Maruti may be able to manufacture 125,000 vehicles if it only produced the Maruti 800, perhaps 110,000 vehicles if it only produced the Omni, and 85,000 vehicles if it only produced the Gypsy. The 100,000 number is an average number to make the capacity measurement relatively easy.

As the amount of customisation and variety in the product mix increases, output-based capacity measures become less useful. Output measures are best utilized when the firm provides a relatively small number of standardized products and services, or when such measures are applied to individual processes within the overall firm.

Let us take another example. We could say that a plastic goods unit turns out plastic goods. Can we therefore unambiguously make a statement of the capacity as the weight of processed output or number of plastic goods per unit period?

Though the capacity of the plastic making unit can be expressed as weight of plastic processed, it would not be accurate because the number will differ according to the mix of products being made. A change in product mix will usually mean a change in capacity also. Also, as there are a variety of plastic goods, coming in different shapes and sizes, number may not be a good measure. Finally, the decision has to be based on judgement or industry practice.

Notes

2. ***Input measures*** are generally used for low-volume, flexible processes.

Example: In a machine shop, capacity can be measured in machine hours or number of machines.

Demand, which invariably is expressed as an output rate, must be converted to an input measure. This conversion is required to compare demand requirements and capacity on an equivalent basis. Capacity, then, may be measured in terms of the inputs or the outputs of the conversion process.

However, converting demand into input measures may be quite difficult. In a general business sense, capacity is most frequently viewed as the amount of output that a system is capable of achieving over a specific period of time.

3.3 Determinants of Effective Capacity

Most of the capacity plans are based on the following:

1. Set time and resource allocation to meet demand;
2. Set strategies for meeting new requirements (new demand, competition, time changes for projects, etc.); and
3. Determine the cost of non-conformance to the plan (waste, time slippage, costs, variance in quality, etc.).

Determinants of effective capacity are:

1. Facilities
2. Product and service factors
3. Process factors
4. Human factors
5. Operational factors
6. Supply chain factors
7. External factors

Table 3.1: Determinants of Effective Capacity

Factors		Issues
Facilities	Design Location	Layout
Product/Service	Design	Product or service mix
Process	Quantity capabilities	Quality capabilities
Human Factors	Job content Job design Training and experience Motivation	Compensation Learning rates Absenteeism and labour turnover Knowledge
Operational	Scheduling Materials Management	Quality Assurance Equipment breakdowns
External Factors	Product standards Safety regulations Unions	Pollution and environmental standards Stability of society/ government

Source: Stevenson

Notes

3.4 Determining Capacity Requirements: Planning Capacity

In the first place, capacity planning has to address the external environment of the firm. One needs to assess the company's situation and think about why the decision to alter capacity should be considered. Is the company responding to a competitor's move?

Example: Indian Airlines and Jet Airways are competing in the same market segment of air travelers. If Indian Airlines increases its frequency of service, it is likely to draw passengers from Jet Airways to Indian Airlines. If Jet Airways does not respond to the Indian Airlines move, it risks losing market share. However, in adding to capacity Jet Airways might also risk under-utilization of capacity. Jet Airways has to assess the risks. On the one hand, Jet Airways does not want to add any more capacity if the present demand levels do not warrant it. On the other hand, Jet Airways might have to do so in order to preserve their market share. Such situations occur regularly in the competitive arena.

In the second place, capacity planning has also to be based on the demands for individual product lines, availability of more efficient technologies, and introduction of new products. As demand for the individual product line increases, there is a need to examine the capacity. Addition of assets to enhance capacity should be considered only when available assets do not meet the gap in capacity envisaged by the management.

Similarly, new technologies can make you uncompetitive. It is important to understand why you are making a change in your capacity levels. Management, before taking a decision on capacity, needs to take the following steps:

1. Forecast demand for individual products within each product line.
2. Calculate the array of assets required to meet product line forecasts.
3. Project availabilities of the existing array of assets over the planning horizon.

Informed capacity decisions can be made only when management knows the ability of its present resources and the bottlenecks in the existing array of assets (system capacity) and what causes them.

An assessment of individual plant capabilities and allocation of production throughout the plant network has to be made.

There must be a high level of confidence in the accuracy of the demand forecast. Once a forecast is available and management determines the point where demand exceeds existing capacity, the time it takes to add on the additional capacity needs to be determined.

If capacity is expected to exceed two years in the future and it takes eighteen months to add that capacity, then management should begin to plan the construction of the additional capacity six months from date. Possibilities are that management can meet the capacity shortfall in the third year, as depicted in Figure 3.1 by using the various tactics for matching capacity to demand, described further.

Finally, investment in assets is also necessary to raise the marginal efficiency of capital employed, till it equals the interest rate.

Example: Reliance Industry's investments in additional capacity were based on a strategy to preempt competition and dominate the market. It expanded capacities in each of its businesses, and expanded capacities even as it was installing the originally planned smaller capacities. Using this strategy, RIL grew into the largest private sector company in the country. In the 90's, no one would have believed that Reliance Industries, a company that went public in the 1970's, would turn out to become the largest private sector enterprise in India.

Therefore, when and how much to increase capacity are critical decisions.

Notes

When

The timing and sizing of expansion are related. Capacity gap analysis is essential in determining when demand will exceed Capacity and by how much. Gap analysis tells you what kind of Capacity you need at given points in time. The temporal dimension of Capacity analysis is important.

In every aspect of business, whether it is in finance, marketing, or production, you can gain competitive advantage through strategies in each area. Capacity offerings can also yield a competitive advantage. You have to determine whether or not you will gain a competitive advantage by introducing that kind of capacity at a particular point in time.

Figure 3.1: Relationship between Capacity Gap and Demand

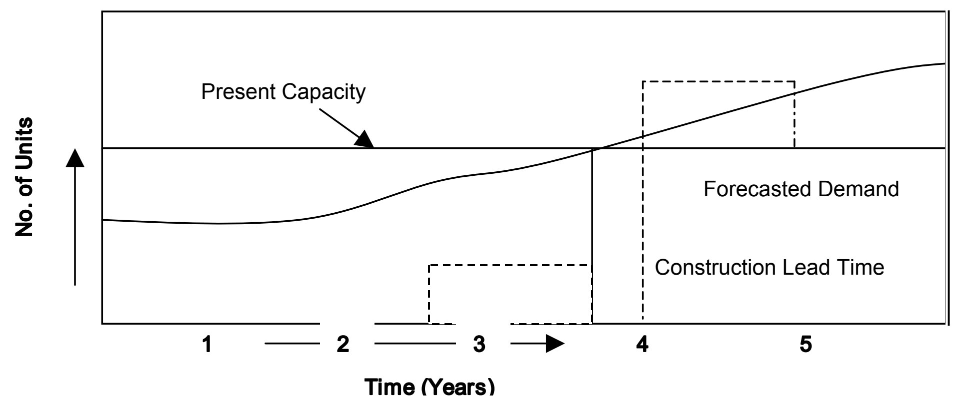
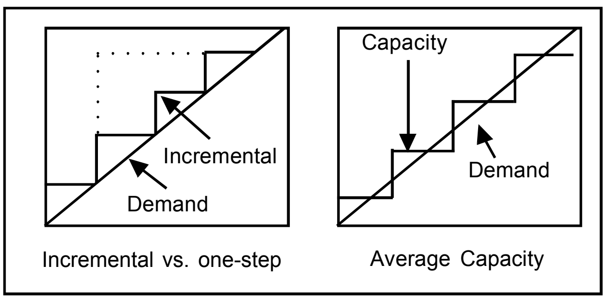


Figure 3.1 shows the relationship between capacity gap and demand. Based on this data, management has to decide when to add capacity. The construction lead time is shown to be 12 months. Should the capacity be added by the start of the second year so that the project is completed by the start of the third year?

The answer is probably 'no', because there would be excess capacity when the project is completed. Management could simply choose not to satisfy all the demand during the third year, if it is consistent with a company policy of building market share. Therefore, perhaps capacity should be added at the end of the fourth year so that capacity and demand can be matched.

Figure 3.2: Capacity Addition Options



Capacity is in some ways a variable and subject to change. This is shown in Figure 3.2. It is possible to raise the operating capacity incrementally depending upon demand. This is because rarely does a plant operate at 100 per cent of its capacity. An industry with an 80 per cent average utilization would have a 20 per cent capacity cushion for unexpected surges in demand or temporary work stoppages.

Notes

Large capacity cushions are common in industries where demand is highly variable, resource flexibility is low, and customer service is important.

Tactics for matching Capacity to demand: Even with good forecasting and facilities built to that forecast, there may be a poor match between the actual demand that occurs and the capacity available.

In the case of seasonal or cyclical pattern of demand, the organization can offer products with complementing demand patterns, that is, products for which the demand is opposite. With appropriate complementing products, perhaps the utilization of facility, equipment, and personnel can be smoothed.

1. Adding people to the production process; if the operation runs two shifts five days a week, then overtime or another shift could be considered.
2. Increasing the motivation of production employees; by providing incentives, involving people in the operating problems, improving job satisfaction etc.
3. Adjusting equipment and processes, which may require purchase of additional machinery or selling or leasing existing equipment.
4. Redesigning the product to facilitate more throughput.
5. Improving the operating rate of equipment; better scheduling, improved operating procedures, or improved quality of raw materials can increase capacity by increasing product yield.

Another important concept to remember is system capacity. To increase the capacity of a system, it is necessary to increase the capacity of only the bottleneck operation. It may be possible to outsource capacity to supplement the bottleneck operation and increase overall capacity. An example of such outsourcing is US banks subcontracting book-keeping operations to Indian companies. Another option is to share facilities.

Did u know? Indian Airlines and Alliance Air share capacity by exchanging aircrafts, as they have different seasonal demands.

When capacity exceeds demand, the firm may want to simulate demand through price reductions or aggressive marketing, or accommodate the market through product changes. When demand exceeds capacity, the firm may be able to curtail demand simply by raising prices, scheduling long lead times and discouraging marginally profitable business. However, in a competitive environment the long-term solution is usually to increase capacity.

The best operating level for a facility is the percentage of capacity utilization that minimizes average unit cost. At higher levels of utilization, demand fluctuations can create havoc. Management would find it difficult to increase market share, if operations cannot deliver the product.

Where it is essential to add capacity in one step, an option is to cut into the lead time.

Example: RIL has created a reputation for setting up projects quickly; it set up its Worsted spinning plant in eight months. Its PFY plant was ready in fourteen months – a feat its collaborators, DuPont, had not managed to achieve anywhere else in the world.

Notes

Caselet

Dalmia Cements Planning to Double Capacity

– by G Naga Shridhar

Dalmia Cements Bharat Ltd (DCBL) will be doubling its production capacity to 12 million tones by the end of 2009 fiscal year commissioning three Greenfield projects.

"The work in three projects coming up at Kadapa (Andhra Pradesh), Ariyalur (Tamil Nadu) and Cuttack (Orissa) is progressing well. These projects will help increase our capacity from current 5.5 million tones to 12 million tones,"Mr Puneet Dalmia, Director, Dalmia Cements Bharat Ltd told Business Line. The Kadapa plant (2.25 million tones) and Cuttack plant (2.25 million tones) would commence production in September 2008 while the Ariyalur project would go on line by March 2009. The company has invested over $500 million in these projects, he said.

In view of the huge demand in the domestic market, the additional capacity would be utilised to cater to markets in Tamil Nadu, Karnataka, Kerala, Orissa, Western Region and Jharkhand. "We are already supplying to these markets and the additional capacity will also go there," Mr Dalmia said.

Though DCBL, which ranks seventh among the top cement companies in India, is exporting oil well cement (used in drilling process) to the Gulf region, the focus is only on domestic markets, he added.

Domestic Capacity

On the demand-supply gap in the market, Mr Dalmia said building domestic capacity is the only solution. "Though there is a talk on cement imports from Pakistan, I feel cement is a local business in the long term and the capacity should be built within the country. I am bullish on a long term view. Next 10 years, the market would be at ease," he said.

The capex pipeline in the country would facilitate additional capacity generation of 100 million tones in next two to four years and the surplus capacity would be visible in next 18 months, he added.

The Tiruchy-based company is expecting to clock a turnover of ₹ 1,200 crore this year. "By the end of 2009-10, we will be crossing ₹ 2,000 crore," Mr Dalmia said.

Source: thehindubusinessline.com

What Kind

What kind of capacity are you going to add? This brings us back to our assessment of alternatives or the trade-offs. Type of capacity can be separated into a technological or engineering question and an economy of scale or business question.

The economy of scale question is a direct link between demand, capacity, and process selection. There is an optimal capacity at which the cost of producing the product is minimized. When demand exists for a product, one or more firms will supply the capacity as long as the price customers are willing to pay is sufficient to cover costs and provide a reasonable profit. A firm would like to bring down its costs to create an entry barrier and preempt competition.

What technological alternatives exist? What kind of technological changes do you anticipate? Can you increase your capacity by introducing new technology as opposed to increasing labour? Technology has become a very important factor in business today.

Qualitative assessment of alternative sources of capacity can be very rewarding; very often, more labour and/or more technology are not the only answers. New options are becoming increasingly available whereby the productivity of existing labour and/or technology can be improved.

How Much

Once the decision to add assets has been taken, the question then arises is, 'How much capacity is needed'? The answer will depend upon what triggered the capacity addition decision. It ties back to the forecast that drove the capacity decision.

Example: The illustration on capacity planning highlights the various factors involved in determining 'how much'. Let us assume that a firm is making a single product. The company's production schedule calls for manufacturing roughly 750 units per week of the product. While there is some fluctuation in this requirement, the fluctuation is small. Production of the product calls for 5 operations performed on 5 different machines. The time requirements for each of these operations are as follows:

The plant is scheduled to work 40 hours a week. The question, is how many machines of each type should we be providing for? Let us consider the case of machine 1.

Actual time used on this machine per week = 40 × 0.82 = 32.8 hours.

The normal time required to perform the operation on this machine

= 0.05 × 110/100 = 0.055 hours.

Therefore, total time required for processing 750 units = 0.055 × 750 = 41.25 hours.

And, number of machines required = 41.25/33.6 = 1.227 machines.

Table 3.2: Illustration on Capacity Planning

Machine	Time per unit (hours)	Machine use ratio	Operator efficiency
1	0.050	0.82	110
2	0.098	0.75	130
3	0.090	0.90	90
4	0.050	0.70	105
5	0.050	0.60	120

This means, we shall either have to provide for 2 machines and thereby create excess capacity, or provide for 1 machine and work on overtime for roughly 9 hours a week. An investment decision can be facilitated with accurate information on the volume of sales for this product. If, for instance, the sales are expected to go up, provision of excess capacity will be justified. If the volume of sales is expected to remain at the present level, it will be worthwhile to examine the economics of using overtime versus adding extra machines.

Similar calculations can be carried out for each of the machines. Based on these calculations, Table 3.3 gives the number of machines required for various operations, without the use of overtime.

Notes

Table 3.3: Number of Machines to be Provisioned

Machine	Number to be Provisioned
1	3
2	7
3	4
4	3
5	3

Even in this simple illustration, we can see that capacity planning has been influenced by several factors such as operation time, operator efficiency, machine use ratio, expected volume of future sales etc.

In addition, most businesses face variability of demand, i.e., peaking by time of day, day of week, month of year. Seasonality in demand creates risks of under-utilization of capacity during the off-peaks and strain on capacity during the peaks. There are both quantitative and qualitative implications in such decisions.

Example: Jet Airways when deciding on their fleet, knowing that there is a peak for a few weeks during puja holidays and during the winter holidays, has to decide whether it is going to equip the fleet and tie in to long-term investment of airplanes for a peak that is only going to last a few weeks during the holiday season.

There is a cost involved in having too much capacity versus the cost of having too little capacity, i.e., the impact on the reputation and growth in the business. We need to evaluate the cost of 'overage' in relation to the cost of 'underage'.

Do the economics favour erring on the side of having too little or too much capacity?

The likelihood is that the economics may favour Jet Airways meeting the capacity during those peaks, because it coincides with the tourist season in India. However, it may turn out to be the opposite also, if the tourist traffic is expected to be small, on account of, say, recent terrorist activity.

The decision about how much capacity to be added is again critical. It is complicated by the uncertainly in the estimates of future demand and technological changes. There can be two extreme strategies:

1. ***Expansionist strategy***, which involves large, infrequent jumps in capacity, and
2. ***Wait-and-see strategy***, which involves smaller, more frequent incremental jumps.

The expansionist strategy, which stays ahead of demand, minimizes the chance of sales lost to insufficient capacity.

In industries where the product or process technology is likely to change rapidly, the organization would not want to build plants that limit its long-term ability to compete. The wait-and-see strategy fits this type of outlook but can erode market share over the long run. The wait-and-see strategy lags behind demands, relying on short-term options such as use of overtime, additional shifts, and outsourcing. There can be short term stretch strategies employed, e.g., stock-outs, and postponement of preventive maintenance to meet any shortfalls.

The decision for incremental expansion should be tempered so that any capacity expansion program is geared towards achieving economies of scale. You have to accept that there are practical limits to economies of scale. The decision has to be restricted to economies of scale that are available under the given circumstances. At that volume the unit cost of production can be reduced, but very often it cannot be minimized.

The expansionist strategy or economic approach generally results in economies of scale and a faster rate of learning. This, with supporting strategies, often helps a firm reduce its costs and compete on price. It also can help increase the firm's market share by preempting competition. Competing firms must sacrifice some of their market share or risk burdening the industry with over capacity. To be successful, however, the preempting firm must have credibility and signal its plans before the competition can act.

Capacity addition is based either on economics or demand.

Notes The economic approach is the basis for the success of Reliance Industries. RIL created world-scale capacity ahead of actual demand, on the basis of the latent demand. This preempted competitors from expanding their capacities. Then RIL went about systematically removing the barriers that were constraining demand. This continuing capacity growth allowed Reliance to dominate the markets in which it competed and also emerge as a low cost manufacturer. RIL emerged as the lowest cost polyester producer in the world. In 1994, its conversion cost for polyester was 18 cents per pound, over 60 per cent lower than its West European, North American and Far Eastern competitors.

Capacity Planning through Decision Trees

Decision Trees are most commonly used in capacity planning. They are excellent tools for helping choose between several courses of action. They provide a highly effective structure within which you can lay out options and investigate the possible outcomes of choosing those options. They also provide a balanced picture of the risks and rewards associated with each possible course of action.

Drawing a Decision Tree

You start a decision tree with a decision that you need to make. Draw a small square to represent this towards the left and draw out lines towards the right for each possible solution. Write that solution along the line, and at the end of each line, consider the results. If the result of taking that decision is uncertain, draw a small circle. If the result is another decision that you need to make, draw another square. Squares represent decisions, and circles represent uncertain outcomes.

Starting from the decision squares on your diagram, draw out lines representing the options that you could select. From the circles draw lines representing possible outcomes. Extend the tree until you have drawn out as many of the possible outcomes and decisions as you can see leading on from the original decisions. An example is shown in Figure 3.3.

Assign a rupee value or score to each possible outcome by estimating its value. Next, look at each circle (representing an uncertainty point) and estimate the probability of each outcome. If you use percentages, the total must come to 100 per cent at each circle. If you have data on past events, you may be able to make rigorous estimates of the probabilities. Otherwise, it can be a best guess. You can also use fractions, but these must add upto 1. Once these values are specified, it is possible to calculate the values that will help you make your decision.

Figure 3.3 also reflects the story of Mr. Raj Kumar Mehta. Mr. Mehta started Mehta Stores in Gurunanak Market in Greater Kailash, primarily selling groceries. His business is growing and

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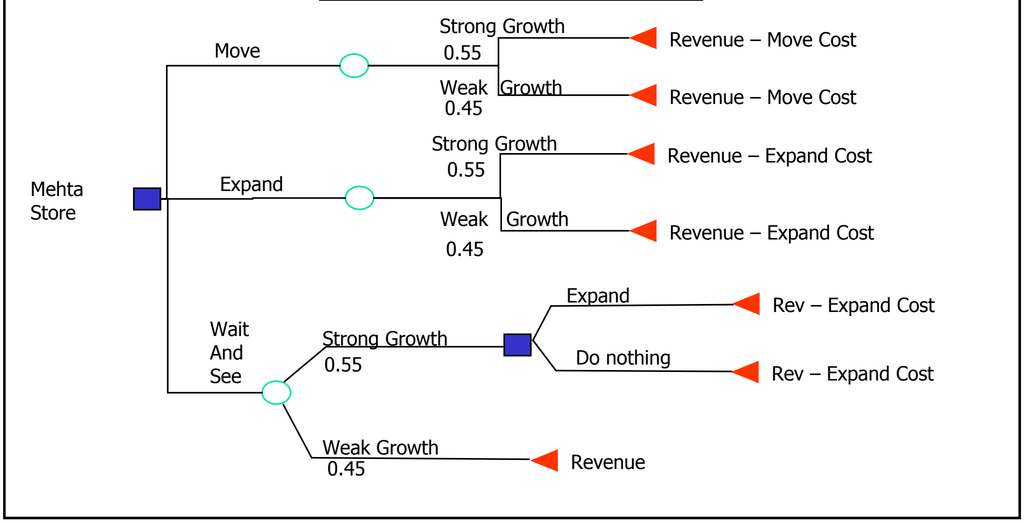
he expects demand to grow further. According to his estimates, the probability of strong growth is 55 per cent and weak growth is 45 per cent.

Figure 3.3: A Decision Tree



He is considering three options. The first is to move to Lajpat Nagar Market. This will require an investment of ₹ 200 lacs. With strong growth, he estimates profits at ₹ 180 lacs annually, while with weak growth the profits would be ₹ 110 lacs. The second option is to expand in Gurunanak Market itself. This will require an investment of ₹ 80 lacs. With strong growth, the profit is estimated to be ₹ 150 lacs annually and with weak growth the profit would be ₹ 90 lacs. His third option is to wait and see. Under those circumstances, he expects profits to be ₹ 145 lacs annually if there is strong growth, and ₹ 80 lacs annually if the growth is weak. His investment in expanding the store would, however, go up to ₹ 90 lacs, if the investment is made next year. Profits with the current store would be ₹ 60 lacs. These options have been tabulated in Table 3.4.

Table 3.4: Mehta Store

Options	Annual Profits		Remarks
	Strong Growth Probability 55%	Weak Growth Probability 45%	
Move	₹ 180 lacs	₹ 110 lacs	Investment (₹ 150 lacs)
Expand	₹ 150 lacs	₹ 90 lacs	Investment (₹ 80 lacs)
Wait & See	₹ 145 lacs	₹ 90 lacs	Investment (₹ 90 lacs next year)

The problem is to find the expected profits over 5 years, and to choose the best alternative. Start on the right hand side of the decision tree, and work back towards the left, multiplying the probability with the expected returns over 5 years. Subtract the cost of each option from the outcome value that you have already calculated. This will give you the benefit of that decision. At any branch, take the best value. For example, in the 'wait and see' option, on the 'strong growth' branch, eliminate the smaller value as has been shown in Figure 3.3.

The calculations for Mehta Store that are depicted in Figure 3.4 are calculated below:

Move, Strong growth = 180 × 5 – 150 = 750

Move, Weak growth = 110 × 5 – 150 = 400

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Expand, Strong growth = 150 × 5 – 80 = 670

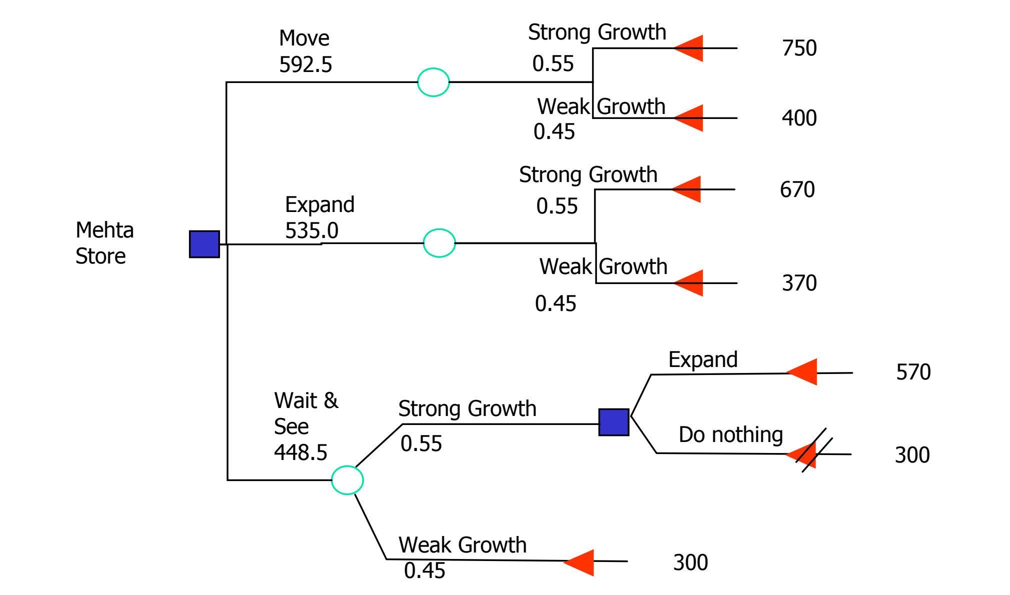
Expand, Weak growth = 90 × 5 – 80 = 370

Wait, strong, expand = 60 +150 × 4 – 90 = 570

Wait, weak, expand = 60 + 90 × 4 – 90 = 330

Wait, lie low, do nothing = 60 × 5 = 300

Figure 3.4: Decision Configuration of Decision Tree



After examining the decision tree and identifying the best options at each branch, the final values are calculated. Multiply, along each branch, the benefits with the probability of the outcome. Complete the set of calculations on each node and record the result.

Move = 750 × 0.55 + 400 × 0.45 = 592.5

Expand = 670 × 0.55 + 370 × 0.45 = 535.0

Wait = 570 × 0.55 + 300 × 0.45 = 448.5

From the calculated decision benefits, the option that has the largest benefit represents the decision. By applying this technique, we can see that the best option is for Mr. Rajkumar Mehta to move to his store to Lajpat Nagar. If Mr. Mehta has an aversion to risk taking, he could also choose on the basis of the highest downside. This would not change his decision in this case as the highest downside is also for the option to move.

Task Visit any one businessman in your locality and find out how he determines capacity for his business to meet customer demands.

3.5 Calculating Processing Requirements

The calculation of the processing requirement by a firm can be explained through this example given in Table 3.5.

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Table 3.5: Calculating Processing Requirements for a Firm

Product	Annual Demand (units)	Standard processing time per unit (hrs)	Required processing time (hrs)
A	600	8	4800
B	800	6	4800
C	900	5	4500

In the example given above, we can see that Product A requires 4800 hrs, B requires 4800 hrs and C requires 4500 hrs of processing time in order to meet annual demand. Thus the total processing requirement of the firm is:

4800 + 4800 + 4500 = 14100 hrs

3.6 Make or Buy Decisions

Processes underlie all activities and hence are found in all organizations and functions. In addition, processes create an inter-connected set of linkages, which connect the external and internal linkages. These linkages are critical because it is not possible for an organization to manufacture or process all its requirements internally.

Example: An automobile manufacturer would seldom consider manufacturing steel although it forms the largest single item used in his product. Nor would an automobile manufacturer manufacture headlights or dashboard instruments.

There are different categories of components, sub-assemblies and other inputs that go into an organization's products. These categorizes are as follows:

1. ***Proprietary items:*** Proprietary items are based on the design of the supplier and used in the end product without change in its basic form or characteristics, for example, headlights, and dashboard instruments.
2. ***Standard components:*** These components are universally designed for general use. For example, standard or customized fasteners are used in most manufactured products.
3. ***Specialty components:*** These components are specialized in nature like the tyres which though used in all vehicles are a speciality product supplied by manufacturers of rubber products.
4. ***Commodity type items:*** These items are supplied either to standard specifications, or customized to the requirements of the user by the supplier. In the case of an automobile manufacturer, steel would constitute such an item. In the case of a steel manufacturer, coking coal, iron ore, limestone, dolomite, etc., would fall in this category.

These items involve large investments and are generally classified as different industries. An investment in such bulk commodities or products, as a vertical integration strategy, is not very common.

The remaining components, sub-assemblies, etc., are those designed for the product. These can be related to what the management considers as:

1. Core, and
2. Non-core activities.

The designation is relative. Core and non-core activities can change depending on the perception of management.

Example: When TELCO put up its Jamshedpur plant, it decided to have its own foundry and forge divisions. These were considered core activities that would reflect upon the quality of the TATA vehicle. However, when TELCO expanded its operations to Pune, the management decided that the investment in a forge plant was not warranted, but a foundry was. Gradually, as the capacity of TELCO increased, the management realized that it would be better off by investing in expansion of its automobile assembly capacity and engine manufacture rather than in forgings or castings. Today, most of the forgings and casting required by TELCO are outsourced.

How many activities – related to the product – that the organization performs depend on its Operations Management strategy and the investments required for backward or forward integration. Not all the components need necessarily be produced or activities be performed by the organization. The manufacture of automobiles, once the most vertically integrated of all businesses, is now among the most disaggregated.

Companies are focusing on the functions they can best perform, and outsource the rest to their partners. Designated non-core activities or secondary activities are often outsourced to a specialist to realize not only higher performance levels but also significant savings.

The Operations Management manager must assess the current performance of a process or asset and also it's potential for improvement so as to take a correct decision regarding outsourcing. He must judge whether suppliers are meeting standards and are abreast with changes in the field. When managed well, assets will follow the operators – inside or outside an organization – that can create the most value.

By shedding assets, some organizations boost their return on invested capital in the short term. They take on the roles as product designers, solutions providers, industry innovators, or supply chain integrators.

But in handing over capital-intensive manufacturing assets to outside suppliers, companies may be losing the very skills and processes that have distinguished them in the marketplace.

Organizations need to critically assess the pros and cons of limiting its manufacturing investments, and ensure the decision implemented improves its company's performance by maximizing the products value.

Example: Nokia has been working towards improving the productivity of its existing assets and integrating its sourcing, sales, and manufacturing efforts.

The company has designed its new Beijing complex, for example, to assemble phones with zero inventories for the supply base that it manages. All components come from their suppliers.

The basis for decisions on outsourcing or vertical integration is knowledge of the true cost of manufacturing goods internally against the cost of acquiring these goods from suppliers. A good decision is based on the assessment by the senior management in the light of the following three dimensions of performance:

1. ***Strategic:*** Does owning or enjoying preferential access to the asset have any strategic importance? How does the company's manufacturing strategy meet the needs of its overall business strategy?

Example: TELCO took a decision on building a forge division at Jamshedpur, when the forging industry in the country was not developed. It gave TELCO the advantage that it was certain of the quality of the TATA vehicle, especially as the steering components were forgings.

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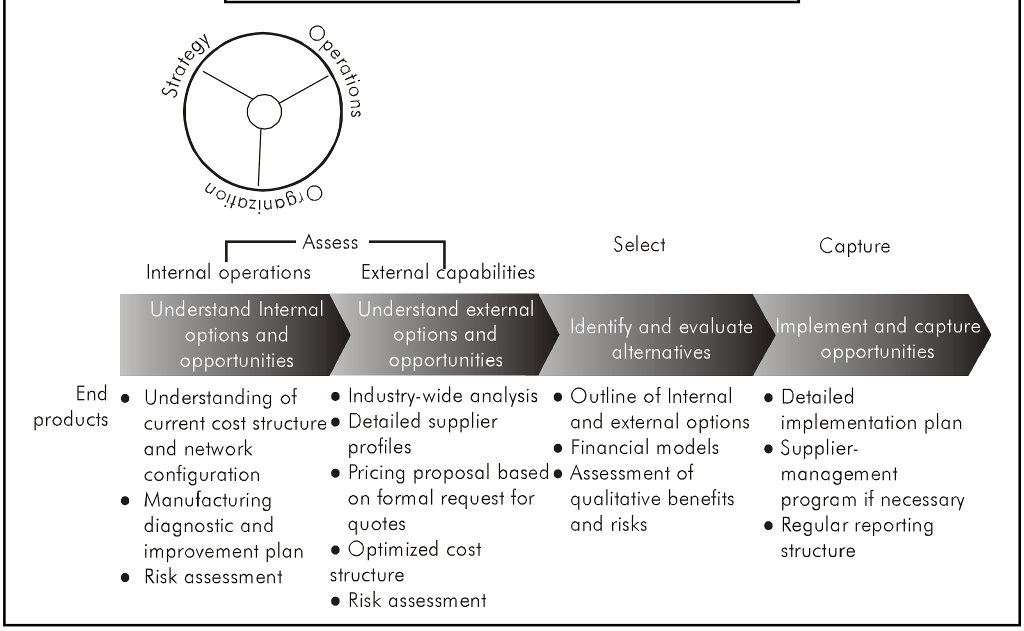
2. ***Operational:*** What are the performance targets and needs of the manufacturing process and the supply chain? What are the optimal supply chain arrangements for meeting those targets? In the case of the TELCO, the closest forging units were Wyman Gordon and Bharat Forge. Both were on the west coast, while Jamshedpur was located on the east coast. Neither of these companies was in a position to come forward in delivering in a crisis.

3. ***Organizational:*** Does the linking of manufacturing strategy to business strategy, achieve results that meet the objectives? Vertical integration is generally attractive when input volumes are high. High volumes permit task specialization and greater efficiency. Established companies, whether they manage reconfigured networks or operate long-standing internal ones, seldom have the skills to transform their supply chains.

Senior managers must use this three – dimensional perspective to assess, first, internal operations; then, external capabilities; and, finally, what combination of the two can create the most value and capture it through managing the network effectively. The schematic representation of the steps and actions involved are depicted in Figure 3.5

Figure 3.5: Framework for Outsourcing Decisions



Source: Adapted from Stephen J. Doig, Ronald C. Ritter, Kurt Speekhals, and Daniel Woolson, *Has outsourcing gone too fair?* The Mckinsey Quarterly, 2001 Number 4.

A new concept of virtual factory is now finding acceptance. Manufacturing activities are carried out in multiple locations by suppliers and partner firms form a part of a strategic alliance or a larger "supply chain." The role of manufacturing in one central plant is eliminated. The virtual factory may have no manufacturing organization, but manages the integration of all steps in the process-no matter where physical production actually takes place. The implications for process planning are profound: This will change the role of Operations Management from monitoring activities in manufacturing to a deep understanding of the manufacturing capabilities of the production network and task co-ordination.

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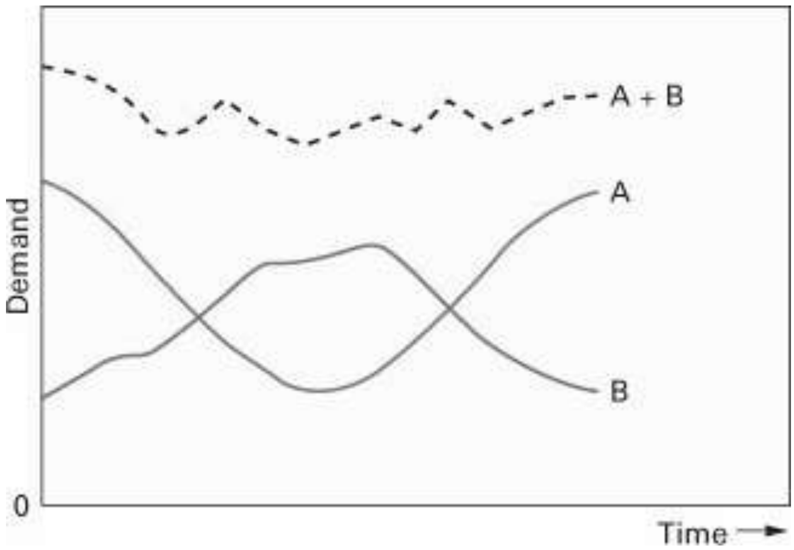
3.7 Developing Capacity Alternatives

1. ***Design flexibility into systems:*** The long-term nature of many capacity decisions and the risks inherent in long-term forecasts suggest potential benefits from designing flexible systems.
2. ***Take stage of life cycle into account:*** Capacity requirements are often closely linked to the stage of the life cycle that a product or service is in.
3. ***Take a "big-picture" (i.e., Systems) approach to capacity changes:***When developing capacity alternatives, it is important to consider how parts of the system interrelate.
4. ***Prepare to deal with capacity "chunks":*** Capacity increases are often acquired in fairly large chunks rather than smooth increments, making it difficult to achieve a match between desired capacity and feasible capacity.
5. ***Attempt to smooth out capacity requirements:*** Unevenness in capacity requirements also can create certain problems.

Figure 3.6: Smoothening of Capacity



6. ***Identify the optimal operating level:*** Production units typically have an ideal or optimal level of operation in terms of unit cost of output.

   Economies of Scale: Economies of scale can also be realized as a result of the company's geographical location. Thus all industries located in the same area could benefit from lower transportation costs and a skilled labour force. Moreover, ancillary industries may then begin to develop, and support such industries.

   External economies of scale can also be obtained if the industry shares technology or managerial expertise. For example, this can lead to the creation of standards within an industry. Just as there are economies of scale, there are also diseconomies of scale. An example of economies and diseconomies of scale in the capacity decision of a hotel is shown in Figure 3.7.

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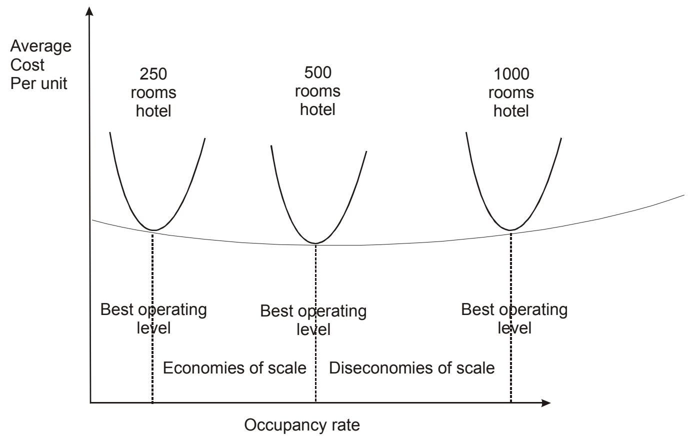
Figure 3.7: Economies and Diseconomies of Scale



7. ***Choose a strategy if expansion is involved:*** Consider whether incremental expansion or single step is more appropriate.

Task Can you find out the names of few companies that completely make all of their own components and some which completely outsource?

3.8 Challenges of Planning Service Capacity

Despite their differences, the concepts of determining system capacity and finding bottlenecks apply to service as well. The principles are the same but in some cases the application is different. Service operations are direct and cannot be inventoried and as a general rule services are produced and consumed simultaneously. This means that service organizations must:

1. Build enough capacity to meet maximum demand, and
2. Use demand management principles so that people will use the services at off-peak times.

If they do not use this approach, they will not be able to satisfy the demand.

Example: A restaurant that has long waiting lines is likely to lose business.

Each of these options has a cost. Building sufficient capacity to meet maximum demand means that a portion of the capacity is used infrequently. Choosing to ignore demand means a loss of customers that may have long-term as well as short-term effects.

In service industries, there is often a high level of interaction with the customer in the production of a service. This can result in uncertainty about processing time. Many services require the customer to come to the service delivery system. This has important implications for the location decision. It also means that capacity decisions should result in adequate space for the customer in the service delivery system.

Notes

Case Study

Apollo Hospitals

The Chief Executive of Apollo Hospitals is attempting to determine the capacity of their out-patients department. The flow of people to the hospital follows this sequence. People arrive at the hospital and park their cars. From records that the hospital keeps, 40 per cent of the guests who come in are visitors to the in-patients wards. The remaining 60 per cent of the arrivals go to the out patients area.

Table 1: Resources in the Out-patient Department

Department/Area	Capacity/Size	Service /Rate
Parking Area	500 Spaces	2.2 persons per car
Registration Area	3 Attendants	5 minutes per patient
Seating Area	6000 sq. ft.	Waiting time 60 minutes
No. of Doctors	30	10 minutes per patient

According to standards that management has developed over the years, 50 per cent of the patients require registering and it takes about five minutes at the registration desk. After that, the patient goes to the specific out-patients department and requires six square feet of seating space including infrastructure. Table 1 depicts the resources of the hospital.

On the average 2.2 people arrive per car; only 90 per cent of the seats in the waiting area are normally available because sometimes patients come in wheel chairs and stretchers. The average stay is sixty minutes. Of the 2.2 people who come in a car, only one person is a patient. There are 30 doctors to attend to the patients. The management anted to know the capacity of the system.

To begin, the capacity of each area can be calculated in terms of persons served per hour.

To calculate the capacity of the system and determine the bottleneck department in this case, we can start by inspecting the department capacities. It is clear that the system's capacity cannot exceed 180 patients/hour because that is the capacity of the number of patients the doctors can treat. This is also the optimum capacity. We start looking at the service capacity of each department. The results are shown in Table 2.

Table 2: Service Capacity of each Department

Department/Area	Capacity (People/Hr.)	Patients/Hr
Parking Area	1100	300
Registration Area	36	72
Seating Area	1000	409
Doctor	396	180

This calculation yields the system capacity, 72 patients per hour. The bottleneck department is the registration area. In spite of the fact that doctors are available, patients cannot see the doctors because they need to register. There is a justification to increase the number of people in the registration area so that the doctors are fully utilized. We can also see that if there is demand for the hospital's services, the hospital could expand to cater to around 400 patients without a major investment in assets.

Contd...

Notes

Question

What are the challenges faced by the management in managing capacity at Apollo and what solution can you suggest?

Solution: There are no problems significantly arising due to the parking area but there are problems while registration and waiting for the doctors. People take 5 minutes to register at the counter and the number of patients waiting to get registered id just double of those who actually get registered in an hour. People may get miffed during this period. The hospital has put in just three attendants who are not able to address the problems well. Therefore the management should look forward to increase the number of attendants at the registration desk.

The problem of waiting line at a particular doctor's chamber is genuine and hard to manage. But however the demand can be pushed to the lean periods or the doctor who has more patients visiting can be asked to visit the hospital for more days. The patients waiting in line to see the doctor can be kept engaged through variety of options like television, magazines etc.

Overall, efficient management in all the sections including the parking lot , can help the hospital manage the demand.

3.9 CVP Analysis

Cost-volume-profit (CVP) analysis is a technique that examines changes in profits in response of changes in sales volumes, costs, and prices. Firms perform CVP analysis to plan future levels of operating activity and provide information about:

1. Which products or services to emphasize
2. The volume of sales needed to achieve a targeted level of profit
3. The amount of revenue required to avoid losses
4. Whether to increase fixed costs
5. How much to budget for discretionary expenditures
6. Whether fixed costs expose the organization to an unacceptable level of risk

CVP analysis begins with the basic profit equation.

Profit = Total revenue – Total costs

Separating costs into variable and fixed categories, we express profit as:

Profit = Total revenue – Total variable costs – Total fixed costs

The contribution margin is total revenue minus total variable costs. Similarly, the contribution margin per unit is the selling price per unit minus the variable cost per unit. Both contribution margin and contribution margin per unit are valuable tools when considering the effects of volume on profit. Contribution margin per unit tells us how much revenue from each unit sold can be applied toward fixed costs. Once enough units have been sold to cover all fixed costs, then the contribution margin per unit from all remaining sales becomes profit.

If we assume that the selling price and variable cost per unit are constant, then total revenue is equal to price times quantity, and total variable cost is variable cost per unit times quantity. We then rewrite the profit equation in terms of the contribution margin per unit.

Profit = P*Q – V *Q – F = (P – V) – Q – F

Where, P is the Selling price per unit

V is the Variable cost per unit

(P – V) is the Contribution margin per unit

Q is the Quantity of product sold (units of goods or services)

F is the Total fixed costs

We use the profit equation to plan for different volumes of operations. CVP analysis can be performed using either:

1. Units (quantity) of product sold
2. Revenues (in Rupees)

3.9.1 CVP Analysis in Units

We begin with the preceding profit equation. Assuming that fixed costs remain constant, we solve for the expected quantity of goods or services that must be sold to achieve a target level of profit.

Profit equation: Profit = (P – V) – Q – F

Solving for Q: Q = F + Profit/P – V = Quantity (units) required to obtain target profit

We must note that the denominator in this formula, (P – V), is the contribution margin per unit.

Example: Suppose that a shirt manufacturer ABC Apparels wants to produce a new warm feel shirt and has forecast the following information.

Price per shirt = ₹ 800

Variable cost per shirt = ₹ 300

Fixed costs related to shirt production = ₹ 5,500,000

Target profit = ₹ 200,000

Estimated sales = 12,000 shirts

We determine the quantity of shirts needed for the target profit as follows:

Quantity = (5,500,000 + 200,000) / (800 – 300) = 11,400 shirts

3.9.2 CVP Analysis in Revenue

The Contribution Margin Ratio (CMR) is the percent by which the selling price (or revenue) per unit exceeds the variable cost per unit, or contribution margin as a percent of revenue. For a single product, it is

CMR = P – V / P

To analyze CVP in terms of total revenue instead of units, we substitute the contribution margin ratio for the contribution margin per unit. We rewrite the equation to solve for the total amount of revenue we need to cover fixed costs and achieve our target profit as:

Revenue = F + Profit/[(P – V)/ P] = F + Profit / CMR

Notes

To solve for the warm feel shirts revenues needed for a target profit of ₹ 200,000, we first calculate the contribution margin ratio as follows:

CMR = (800 – 300)/ 800 = 0.625

A contribution margin ratio of 0.625 means that 62.5% of the revenue from each bike sold contributes first to fixed costs and then to profit after fixed costs are covered.

Revenue = (5,500,000 + 200,000)/0.625 = ₹ 9,120,000

We check to see that the two results are identical by multiplying the number of units (11,400) times price (₹ 800) to obtain the revenue amount (₹ 9,120,000).

The contribution margin ratio can also be written in terms of Total Revenues (TR) and Total Variable Costs (TVC). That is, for a single product, the CMR is the same whether we compute it using per-unit selling price and variable cost or using total revenues and total variable costs. Thus, we can create the following mathematically equivalent version of the CVP formula.

Revenue = F + Profit / [(TR – TVC)/ TR]

For warm feel shirt we could use the forecast information about volume (12,000 bikes) to determine the contribution margin ratio.

Total revenue = ₹ 800 × 12,000 shirts = ₹ 9,600,000

Total variable cost = ₹300 × 12,000 bikes = ₹ 3,600,000

Total contribution margin = ₹ 9,600,000 – ₹ 3,600,000 = ₹ 6,000,000

Contribution margin ratio = ₹ 6,000,000/₹ 9,600,000 = 0.625

3.9.3 Break-even Point

Managers often want to know the level of activity required to break even. A CVP analysis can be used to determine the breakeven point or level of operating activity at which revenues cover all fixed and variable costs, resulting in zero profit. We can calculate the breakeven point from any of the preceding CVP formulas, setting profit to zero. Depending on which formula we use, we calculate the breakeven point in either number of units or in total revenues.

For warm feel shirts, breakeven points are:

Breakeven quantity = (₹ 5,500,000 + 0)/(₹800 – ₹ 300) = 11,000 shirts

Breakeven revenue = (₹5, 500,000 + 0)/0.625 = ₹ 8,800,000

3.10 Summary

- Capacity planning should be solely based on the principle of maximizing the value delivered to the customer.
- Theoretical capacity is what can be achieved under ideal conditions for a short period of time. Under these conditions, there are no equipment breakdowns, maintenance requirements, set up times, bottlenecks, or worker errors.
- Normal Capacity describes the maximum producible output when plants and equipment are operated for an average period of time to produce a normal mix of output.
- Top management often finds it desirable to express addition to new capacity in terms of money value of sales.

Notes

- No matter how broadly we may define capacity, in the final analysis, in manufacturing, it has to come down to capacity of individual machines.
- To estimate Capacity, you must first select a yardstick to measure it. The first major task in Capacity Measurement is to define the unit of output.
- Whatever the measure, the Capacity decision is critical to the management of an organization because everything from cost to customer service is measured on the basis of the Capacity of the process, once the Capacity is determined.
- Capacity planning has to address the external environment of the firm. One needs to assess the company's situation and think about why the decision to alter capacity should be considered.
- The timing and sizing of expansion are related. Capacity gap analysis is essential in determining when demand will exceed Capacity and by how much.
- When capacity exceeds demand, the firm may want to simulate demand through price reductions or aggressive marketing, or accommodate the market through product changes.
- Decision Trees are most commonly used in capacity planning. They are excellent tools for helping choose between several courses of action.
- Processes underlie all activities and hence are found in all organizations and functions. In addition, processes create an inter-connected set of linkages, which connect the external and internal linkages.
- Despite their differences, the concepts of determining system capacity and finding bottlenecks apply to service as well. The principles are the same but in some cases the application is different.
- Cost-volume-profit (CVP) analysis is a technique that examines changes in profits in response to changes in sales volumes, costs, and prices.

3.11 Keywords

Capacity: Maximum output of a system in a given period under ideal conditions.

Contribution Margin: Total revenue minus total variable costs.

CVP Analysis: Technique that examines changes in profits in response to changes in sales volumes, costs, and prices.

Decision Tree: Provide highly effective structure within which you can lay out options and investigate the possible outcomes of choosing those options.

Effective Capacity: Capacity, which a firm can expect to achieve, given its product mix, methods of scheduling, maintenance, and standards of quality.

Efficiency: Measure of actual output over effective capacity.

Expansionist Strategy: It involves large, infrequent jumps in capacity.

Input Measures: Generally used for low-volume, flexible processes.

Normal Capacity: Maximum producible output when plants and equipment are operated for an average period of time to produce a normal mix of output.

Notes

Output Measures: Usual choice for high-volume processes.

Rated Capacity: Measure of the maximum usable capacity of a particular facility.

Theoretical Capacity: That can be achieved under ideal conditions for a short period of time.

Wait-and-see strategy: Involves smaller, more frequent incremental jumps.

3.12 Self Assessment

State whether the following statements are true or false:

1. If you are the operations manager of a firm, then theoretical capacity will interest you more.
2. Rated capacity is dependent on efficiency of the firm's capacity.
3. A huge company with turnover in crores is most likely to use output measures for its capacity.
4. The legal and environmental issues can form a major hindrance in operating at effective level of capacity.
5. Renting a part of school premises for running coaching classes on holidays is an effective way to match capacity to growing demand.
6. Wait-and-see strategy is more competent than expansionist strategy.
7. The concept of decision tree is based on guess work.
8. Ball bearings used in automobiles are a type of specialised component.
9. If the capacity is increased to a great extent diseconomies of scale come into play.
10. One of the major challenges posed by services capacity planning is that they can't be inventoried.

Fill in the blanks:

11. If the rated capacity is 20000 products/month and the efficiency and utilization are both 80%, then the capacity is……………………
12. Capacity planning finds its base mainly in……………………..
13. The items like silver, gold, milk etc. are all ……………………types.
14. Profits= Total Revenue- (…………………+…………………..)
15. If we subtract the value of variable costs form the total revenues earned we will get the…………………….

3.13 Review Questions

1. "Product design, capacity and process selection have a direct relationship". Substantiate.
2. How capacity planning has become a strategic tool in the operations function?
3. Why theoretical capacity is rendered meaningless for any operations manager?
4. "To estimate capacity, you must first select a yardstick to measure it". Discuss
5. "Capacity planning has to address the external environment of the firm". Why?
6. "Capacity offerings can also yield a competitive advantage". Comment.

Notes

7. Compare and contrast the expansionist and wait-n-see strategy.
8. Critically examine the use of decision trees to determine capacity.
9. "The basis for decisions on outsourcing or vertical integration is knowledge of the true cost of manufacturing goods internally against the cost of acquiring these goods from suppliers". Discuss.
10. What are the basics that must be kept in mind while developing capacity alternatives?
11. Calculate the quantity to be produced and contribution margin from the data given below:
    (a) Price per unit = ₹ 3500
    (b) Fixed Costs = ₹ 10,20,000
    (c) Estimated Profits= ₹ 3,90,000
    (d) Total Cost = ₹ 30,00,000
    (e) Targeted sales= 20,000 units
12. Complete the table given below:

Product	Monthly Demand in units	Standard processing time per unit in hrs	Annual processing time in hrs
A	200	4	
B		5	5000
C	180		6000
D	220	8	

13. 'Capacity is modified in response to demand'; and 'demand is modified in response to capacity'. Which of these two statements do you consider to be correct? Why?
14. A factory owner is considering drilling a tube well. In the past, only 70 per cent of the wells drilled up to a depth of 200' were successful in that area. However, on finding no water some had drilled further up to 250', but only 20 per cent struck water at that depth. The prevailing cost of drilling per foot is ₹ 500. The factory owner has calculated that in case he does not get water from the tube well, he will have to pay ₹ 1,50,000 from the public supply system.

    The following decisions can be taken:
    (a) Do not drill the well
    (b) Drill up to 200', and
    (c) If no water is found, drill up to 250'.

    Draw an appropriate Decision Tree and determine what should be the strategy of the factory owner.
15. What are the issues involved in designing a Mall? What lessons do they give you in planning capacity for other service companies?
16. A glass factory specializing in crystal is experiencing a substantial backlog, and the firm's management is considering three courses of action:
    (a) Arrange for subcontracting
    (b) Construct new facilities
    (c) Do nothing (no change)

Notes

The correct choice depends largely upon demand, which may be low, medium, or high. By consensus, management estimates the respective demand probabilities as 0.1, 0.5, and 0.4.

The management also estimates the profits when choosing from the three alternatives (A, B, and C) under the differing probable levels of demand. These profits, in thousands of dollars are presented in the table below:

	0.1	**0.5**	**0.4**
	Low	**Medium**	**High**
A	10	50	90
B	-120	25	200
C	20	40	60

Which alternative should the management choose?

Answers: Self Assessment

1. False
2. True
3. True
4. True
5. True
6. False
7. False
8. True
9. True
10. True
11. 31250
12. Demand
13. Commodity
14. TVC + TFC
15. Contribution Margin

3.14 Further Readings

Books

N G Nair, *Production and Operations Management*

Stevenson, *Operations Management,* 8th Edition, Tata McGraw Hill

Upendra Kachru, *Production and Operations Management – Text and Cases,* Excel Books, New Delhi

Online links

logistics.about.com/od/.../a/Measuring_Capacity.htm

www.enotes.com/management.../make-buy-decisions

www.teamquest.com/pdfs/whitepaper/tqwp23.pdf

www.marcbowles.com/courses/adv.../amc6_ch2tfour6.htm

www.wiley.com/college/sc/eldenburg/ch03.pdf

Unit 4: Process Selection and Facility Layout

Notes

CONTENTS

Objectives

After studying this unit, you will be able to:

- State different types of manufacturing layouts
- Explain flexible manufacturing system
- Discuss Computer Integrated Manufacturing (CIM)
- Understand Assembly Line Balancing
- Describe facilities layout and repetitive process layout

Notes

- Explain repetitive product or line layout and design
- Discuss fixed position layout and cellular layout or group layout
- Explain combination layout and closeness rating
- Discuss other service layouts

Introduction

The design of manufacturing processes and service delivery systems cannot be made without considering product design decisions. Many aspects of product design can adversely affect operations performance. New products and services must be produced and delivered efficiently, at low cost, on time, and within quality standards. Process technology decisions relate to organizing the process flows, choosing an appropriate product-process mix, adapting the process to meet strategic objectives, and evaluating processes. A process is any part of an organization that takes inputs and transforms them into outputs. The value the process generates is the difference between what the final product is worth to the customer and its initial value. The objective of the process is to provide the maximum overall value to the customer in the product. The process is called out in a designed layout called facility layout and firms design their layouts in accordance to the process they choose to follow.

4.1 Types of Manufacturing Processes

Processes seldom stand alone. Generally, each process is a single activity or a group of activities that are linked together in different patterns to produce the final product. Processes need to be categorized to describe the patterns that are formed when they are linked together. This categorization helps in understanding the similarities and differences between processes.

There are a number of ways to categorize a process. Categorization is based on whether it is a single-stage or a multiple-stage process.

Single-stage Process

If the forging machine were viewed as a simple black box, it would be categorized as a single-stage process. In this case, all activities that are involved in forging the component would be analyzed using the different factors to determine the overall economics and to represent the process parameters.

Multiple-stage Process

It has multiple groups of activities that are linked through flows. The connecting rod, seen as a component for the engine, would have two stages for its manufacture; the 'forging' stage and the 'machining' stage. The term stage indicates multiple activities that are pulled together for analysis purposes.

Example: ECIL manufactures the CYBER series of mainframes of Control Data Corporation, USA, a supercomputer, under the name of MEDHA. Most of the processes used in ECIL for the manufacture of this equipment are complex multi-stage processes.

A multiple-stage process normally requires to be buffered internally if the processes are not continuous. Buffering refers to a storage area where the output of a stage is placed before being used in a downstream stage. Buffering allows the stages to operate independently. If one stage feeds a second stage with no intermediate buffer, then the assumption is that it is a continuous

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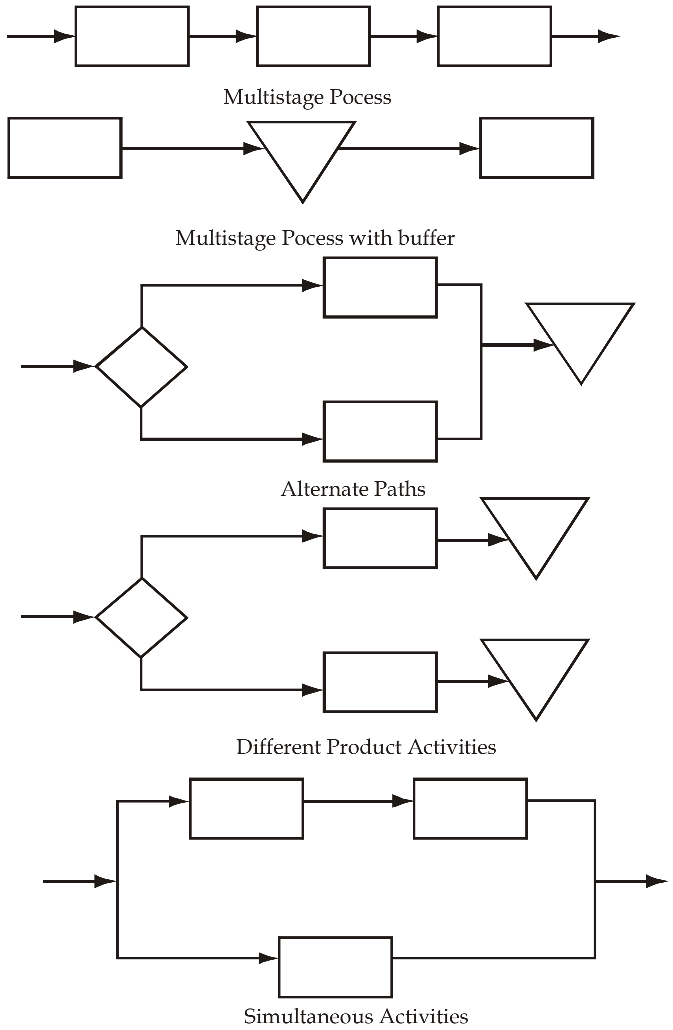
process and the two stages are directly linked. In a continuous process, the most common problems are 'blocking' and 'starving'.

Figure 4.1: Types of Processes



Blocking occurs when the activities in the stage move faster than that of the next stage and it becomes necessary to stop the process because there is no place to deposit its output.

Starving occurs when the activities in a stage must stop because there is not sufficient output from the stage preceding it.

Consider a multiple stage process with two stages. The first stage has a cycle time of 1 minute and 30 seconds and the second has a cycle time of 1 minute. If this process needs to produce 300 units, then for each unit produced, the second stage would be blocked for 30 seconds.

What would happen if an inventory buffer of 100 units was placed between the two stages? In this case, the first stage would complete the 200 units in 300 minutes (1 minute and 30 seconds/ unit × 200 units). During these 300 minutes the second stage would complete 300 units (1 minute/ unit). This would mean that the inventory would go down to zero after the first 300 minutes. All the units produced thereafter would have to wait for 30 seconds per unit for the process to continue.

Notes

The first stage in this case is called a bottleneck because it limits the capacity of the process. This assumes no variability in the cycle time. With the relatively low 67 per cent utilization on the first, second, variability would have little impact on the performance of this system.

Often activities, stages, and even entire processes are operated in parallel. For example, operating two identical forging presses in parallel would theoretically double the capacity of forging connecting rods. In many machine shops, multiple activities are carried out at the same time. These units are called machining centers. When analyzing a system with parallel activities or stages, it is important to understand the context. In the case where parallel processes represent alternatives it should be clearly indicated by a decision box.

Typology of Processes

There are many ways in which processes can be categorized. They can be categorized on the basis of their orientation, e.g., market orientation or manufacturing processes; they may also be categorized on the basis of the production methodology or customer involvement. Given below are the various categorizations of processes that are commonly used:

Processes by Market Orientation

Processes can also be categorized on the basis of four market orientations:

1. ***Make to Stock (MTS):*** The goods usually are standard, mature products with few product customization options. As a general rule, 'make to stock' products compete primarily on the basis of cost and availability.

Example: Such products include most retail goods such as breakfast cereals, milk, shirts, jeans, and office desks.

The Consumer Electronics Group of ECIL manufactures colour and black and white televisions that are also 'make to stock' items.

2. ***Assemble to Order (ATO):*** 'Assemble to order' products are standard items that are assembled from in-stock subassemblies. This allows customers to specify a wide range of options.

Example: Many camera dealers can 'assemble' any configuration of a single lens reflex camera from a basic body. The customer specifies the exact type of lens desired, or the viewing system, etc.

In marketing, this approach is referred to as postponement. Successful sellers of 'assemble to order' products must keep their assembly lead times as short as possible. The Communication Systems Group (CSG) of ECIL manufactures two-way wireless communication sets (HF, VHF, UHF); microwave instruments and components; various kinds of antennae including microwave antennae for satellite communications, fax equipment, SPC Telex equipment, frequency modulated antennae, analog/digital microwave communication systems, and air traffic control equipment. These are basically 'assemble to order' types of products.

3. ***Make to Order (MTO):*** Make to order products are made from previously engineered designs, but are made only after an order has been received. 'Make to order' products are used when a standard product is: too costly to stock, has too uncertain demand, or will deteriorate if stocked on a shelf.

Example: Goods made using the 'Make to order' products market orientation are: commercial airplanes, prescription glasses, etc.

The lead time depends on whether or not the firm can and will stock raw materials in anticipation of orders. The company saves by not having to commit resources in production until a firm order is received. ECIL manufactures the CYBER series of mainframes, MEDHA, which are 'make to order' products.

4. ***Engineer to Order (ETO):*** This market orientation is used to make unique products that have not been previously engineered. Extensive customization to suit the customer's need is possible, but only if the customer is willing to wait for this addition stage in the value creation process.

Example: ETO products include: specialized industrial equipment, hand-built furniture, etc.

A producer of ETO products must wait for customers to place orders before beginning any activity. As a result, the customer bears the entire cost of the total product delivery lead time. In other words, the external lead time often exactly equals the total product delivery lead time. The Control Systems, Communications and Computer Groups of ECIL make products that are 'engineered to order'.

Processes as Production Systems

A production system refers to how an organization organizes material flow using different process technologies. There are five major types of production systems that have been generally identified. They are:

1. ***Project:*** These are generally one-off projects. It is based on extensive customization that is suited to the customer's need. Many construction projects, project management contracts, shipbuilding and civil engineering projects fall in this category.

Example: Larson and Toubro's main business is executing projects. Much of the work is carried out at site rather than in a factory. All equipment, tools, materials, labour, etc., are placed at the site itself. Infosys sends its teams to the customer's facilities to install, test, and customize its software.

2. ***Job Shop:*** Job shop production is characterized by processing of small batches of a large number of different products, most of which require a different set or sequence of processing steps. Production equipment is mostly general purpose to meet specific customer orders. Highly skilled labour is needed to handle the processes, as the variety and product range are generally very high.

   Commercial printing firms, machine shops, and die, jigs and fixture making, etc., are examples of this type of structure.

Example: Thomson Press operates on the basis of specific customer orders; Tools and Equipment makes jigs and fixtures as per the design and requirements of its clientele. Tata Consultancy Services (TCS) produce different types of software, based and customized to each client's requirements.

Notes

3. ***Batch Production (Disconnected Line):*** Production is in discrete parts that are repeated at regular intervals. Essentially, it is somewhat like a standardized job shop. Such a structure is generally employed for relatively stable line of products, each of which is produced in medium volume, either to customer order or for inventory. The process has the ability to switch over from one product to another with relative ease. Though mostly general-purpose machine are used, they are supported with specially designed jigs and fixtures. The skill level of labour is high but not critical.

Example: Equipment like X-ray machines, earth moving and material handling equipment, electronic devices, etc. Wipro GE manufactures medical equipment and ECIL manufactures mainframe computers using batch production.

This is also applicable to many small-scale enterprises or many chemical processes, etc., e.g., Oracle or People Soft produce CDs with standard software in batch productions depending on the demand.

4. ***Assembly Line:*** An assembly line is a mass production process. On assembly line, production follows in a predetermined sequence of steps, which are continuous rather than discrete. The product moves from workstation to workstation at a controlled rate, following the sequence needed to build the product. The product variety is low and special purpose tools and equipment is normally employed. When other processes are employed in a line fashion along with assembly, it is commonly referred to as a production line.

Example: Automobiles, appliances like washing machines, televisions, etc. Maruti makes cars on an assembly production line; ECIL makes electronic components and McDonald's its burgers using the same concept.

5. ***Continuous Flow:*** Continuous production is common in the food processing industry, and in industries involving undifferentiated materials such as petroleum and chemicals. Most bulk products are manufactured using continuous flow production. Generally, online control and continuous system monitoring is needed. Such processes are usually highly automated and, in effect, constitute one integrated machine. Shutdowns and start-ups are very expensive in this production mode, and need to be avoided.

Example: The Reliance Petrochemical complex at Patalganga and the Thermal Power Plants operated by NTPC.

6. ***Cell Manufacturing (Group Technology):*** A cell is a self-sufficient unit, in which all operations required to make components or complete products can be carried out. It is like a mini-factory within the factory, which is managed by a cell team. TI Cycles reorganized its manufacturing into cells to serve other operations. Thus cell manufacturing creates a client-server relationship between the different components of the production system. Cell layouts can be U-shaped or a segment of a line (a product or sub-assembly stage) allowing a self-organizing, multi-skilled group of fewer people to manage the operation. Shorter processing times, better team attention to quality problems, reduction of work in progress, lower handling costs and simpler scheduling can be achieved. Built in spare plant capacity (redundancy) or providing additional machines to a cell can accommodate small changes or fluctuations in demand and bring benefits.

7. ***Flexible Manufacturing Systems (FMS):*** A flexible manufacturing system generally consists of a number of CNC machine tools and a materials handling system that is controlled by one or more dedicated computers. A typical flexible manufacturing system can completely process the members of one or more part families on a continuing basis without human

intervention. FMS brings flexibility to manufacturing so that a part can be produced when the market requires it. The system is flexible enough to suit changing market conditions and product type without buying other equipment.

Computer-aided manufacture and control enables to set up time on machines or minimize changeover procedures. Computers control machines so that they can respond to pre-programmed instructions. Parts or components are designed using Computer Aided Design software (CAD) and the data from design specification provides the input to generate instructions to computer-controlled machines. Due to this, the production of frequent, small batches is possible and machine availability can be better scheduled in response to customer orders and unit production costs can be kept low.

A production line assembling cars, e.g., Maruti, can switch from producing large batches of one model of car to another model with a different shape and arrangement of sub-assemblies within minutes and multi-skilled workers can re-configure their work stations with required materials.

Processes and Customer Involvement

Many processes are designed keeping in mind that value is provided by involving the customer in the delivery of the final product. The involvement may range from self-service to the customer by deciding the time and place where the service is to be provided.

1. ***Self Service:*** Morning store in Delhi started a new trend in buying groceries by introducing self-service. This was a change from the traditional system where the customer gave a list to the grocer who then supplied the items. Morning store found that they not only saved money by not employing people, but also they increased sales due to a high level of impulse buying. Though traditionally self-service was meant to save money and thereby provide greater value to the customer, it soon found application for other strategic considerations also.

   In USA and Europe, manufacturers of goods such as toys, bicycles, furniture, etc., offer products where the customer performs the final assembly. The rationale behind such decisions is that the manufacturer saves on production, shipping and inventory costs, and these costs are passed on to the customer. This concept is slowly finding applications in developing countries also.

2. ***Product Selection:*** Business organizations are increasingly attempting to involve their customers in the product design by providing them different options for customization.

Example: Maruti Udyog Limited, the premier automobile manufacturer in India, in a bid to retain its premier position in the market, is offering customization for its basic car model, the Maruti 800, even before consumers have demanded it. The customer has been offered a choice of color combinations, material and functionality add-ons. The facility is not only available on new purchases but also available for in-use cars so that the company retains the goodwill of its existing customers.

   This type of option has implications both in product as well as process design decisions.

3. ***Partnerships:*** Organizations engage in an active dialogue with customers using new emerging technologies. Customers are increasingly becoming partners in creating value. Customers can now decide the time and location where the service or product is to be delivered. Pricing and billing systems are modified to customer convenience.

Notes

The relationships in the supply chain are also changing. Unlike the traditional relationship where the retailer was subservient to the manufacturer, sellers are now demanding a distribution chain management where they can cut out the requirements of buffer stocks.

In addition, the sellers can exert enormous influence on manufacturers in terms of what they should produce. Organizations, in turn, are increasingly using distributors and suppliers in the process of developing new products.

In a number of products, there is a shift towards a range of other non-price factors to provide increased customer value.

Other Basic Manufacturing Processes

A way to categorize manufacturing processes is based on what they do. At the most basic level, the types of processes do the following things:

1. ***Analytic processes:*** An analytic process breaks down raw material into its constituent parts, e.g., refining crude.
2. ***Synthetic processes:*** A synthetic process combines basic parts into larger products, e.g., manufacture of automobiles, radios, televisions, etc.
3. ***Modifying processes:*** These processes modify the physical characteristics of materials upon which labour or operations are performed, e.g., forming processes, machining processes, heat treatment processes, surface-treating processes, joining processes, etc. Sometimes, basic processes are described as conversion or fabrication processes. Steel making is a conversion process while making sheet metal into car body panels is a fabrication process.
4. ***Assembly processes*** join parts already processed into products or services, e.g., preparing fast food, a radio or a car.
5. ***Testing processes*** test to ensure products meet specifications. Though not strictly speaking fundamental processes, these are widely mentioned as a major activity and are included here for completeness.

4.2 Flexibility in Manufacturing Systems

Flexibility in manufacturing is the ability of a manufacturing system to respond at a reasonable cost and at an appropriate speed, to planned and unanticipated changes in external and internal environments. In other words, flexibility relates to the ability of the system to create products capable of meeting a customer's need.

Flexibility means to produce reasonably priced customized products of high quality that can be quickly delivered to customers. For example, with make-to-stock market orientation; flexibility is the ability to provide the customer sufficient finished good choices. If the right product is available too late or at a cost that one cannot afford, it will be an order loser. Many different concepts of flexibility exist. They are:

1. ***Mix Flexibility:*** The ability of a system to present a wide range of products or variants with fast setups.
2. ***Changeover Flexibility:*** The ability of an Operations Management system to introduce a large variety of major design change quickly within existing facilities.
3. ***Modification Flexibility:*** The ability of the transformation process to implement minor product design changes, even after the product has been delivered.

4. ***Volume Flexibility:*** The ability of the transformation process to profitably accommodate variations in production quantities. Systems with high fixed costs beget inflexibility since the firm will always be striving to maintain high utilization rates.

5. ***Rerouting Program Flexibility:*** The ability of the Operations Management systems to respond to factors of product shortfall, such as equipment breakdowns, labour absenteeism, or a delayed raw materials shipment.

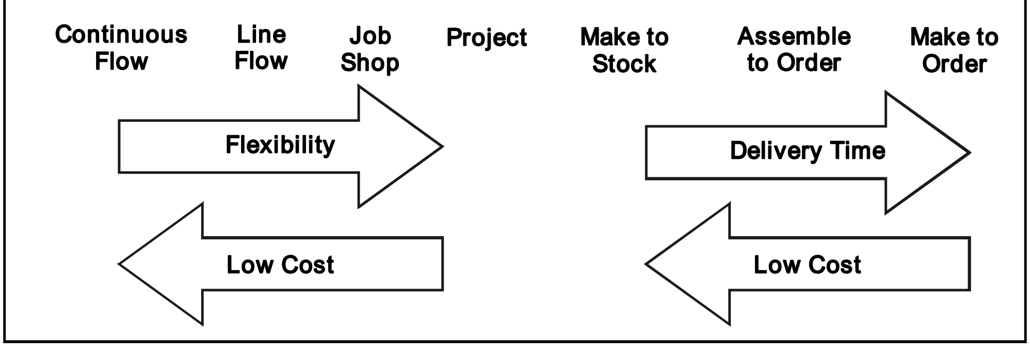
6. ***Material Flexibility:*** The ability of transformation processes to adjust for unexpected input variations.

7. ***Flexibility Responsiveness:*** The ability of the firm and its managers to change the strategic objectives in response to changes in the market place.

Enhancing flexibility requires co-operation both inside and outside the firm. For example, a suitably designed product greatly enhances the ability of the operations manager, to implement and compete, using product modification flexibility. To emphasize volume flexibility, a firm needs the support of suppliers. Success in enhancing mix or changeover flexibility depends on strong links with the internal marketing function and with customers and its supply chain management system.

Different processing strategies have different impact on the timeliness of providing the product to the customer. Reductions in lead times affect flexibility; improvements in flexibility impact the timeliness of providing the product to the customer. Flexibility also plays a significant part in determining the cost of the product. The relationship between system flexibility, timeliness, and cost is shown in Figure 4.2.

Figure 4.2: Relationship between Cost and Flexibility



Measures of overall system flexibility show how parameters such as machine utilization, range of products manufactured, customer order turn around time and new product introduction frequency influence the product. Based on these criteria, there are three levels of manufacturing flexibility.

1. ***Basic flexibility:*** This includes different parameters including:

   (a) *Machine flexibility*, which enable the machine to process various operations with ease;

   (b) *Material handling flexibility* which measures the ease with which different part types can be transported and properly positioned at the various machine tools in a system; and

   (c) *Operation flexibility* that measures the ease with which alternative operation sequences can be used for processing a part type.

Notes

2. ***System flexibility:*** System flexibility consists of parameters like:
   (a) *Volume flexibility* which is a measure of the system's capability to be operated profitably at different volumes of the existing part types;
   (b) *Expansion flexibility* is the ability to build a system and expand it incrementally;
   (c) *Routing flexibility* is a measure of the alternative paths that a part can effectively follow through a system;
   (d) *Process flexibility* measures the volume of the set of part types that a system can produce without incurring any setup; and
   (e) *Product flexibility* which is the volume of the set of part types that can be manufactured in a system with minor setup.
3. ***Aggregate flexibility:*** This comprises of:
   (a) *Program flexibility* which is the ability of a system to run for reasonably long periods without external intervention;
   (b) *Production flexibility* is the volume of the set of part types that a system can produce without major investment in capital equipment; and
   (c) *Market flexibility* that determines the ability of a system to efficiently adapt to changing market conditions.

Flexibility issues are important in considering additional investment in plant or equipment. Selection of methods to improve flexibility should reflect how the firm competes. Each type of flexibility generates value differently, so a firm should emphasize categories of flexibility that customers value most. It should be understood that no firm can excel on all dimensions of flexibility.

Task Enlist the types of businesses that use self-service, product selection and partnerships with customers. Give examples of brands.

4.3 Computer Integrated Manufacturing (CIM)

Computer Integrated Manufacturing, known as CIM, is the phrase used to describe the complete automation of a manufacturing plant, with all processes functioning under computer control and digital information tying them together. It was promoted by machine tool manufacturers in the 1980's and the Society for Manufacturing Engineers (CASA/SME). Quite often it was mistaken for the concept of a "lights out" factory. It includes computer-aided design/computer-aided manufacturing, CAPP, computer-aided process planning, CNC, computer numerical control machine tools, DNC, direct numerical control machine tools, FMS, flexible machining systems, ASRS, automated storage and retrieval systems, AGV, automated guided vehicles, use of robotics and automated conveyance, computerized scheduling and production control, and a business system integrated by a common data base.

The heart of computer integrated manufacturing is CAD/CAM. Computer-aided Design and Computer-aided Manufacturing systems are essential to reducing cycle times in the organization. CAD/CAM is a high technology integrating tool between design and manufacturing. CAD techniques make use of group technology to create similar geometries for quick retrieval. Electronic files replace drawing rooms. CAD/CAM integrated systems provide design/drafting, planning and scheduling, and fabrication capabilities. CAD provides the electronic part images, and CAM provides the facility for tool path cutters to take on the raw piece.

The computer graphics that CAD provides allows designers to create electronic images which can be portrayed in two dimensions, or as a three dimensional solid component or assembly which can be rotated as it is viewed. Advanced software programs can analyze and test designs before a prototype is made. Finite element analysis programs allow engineers to predict stress points on a part, and the effects of loading.

Once a part has been designed, the graphics can be used to program the tool path to machine the part. When integrated with an NC postprocessor, the NC program that can be used in a CNC machine is produced. The design graphics can also be used to design tools and fixtures, and for inspections by coordinate measuring machines. The more downstream use that is made of CAD, the more time that is saved in the overall process.

Generative process planning is an advanced generation of CAD/CAM. This uses a more powerful software program to develop a process plan based on the part geometry, the number of parts to be made, and information about facilities in the plant. It can select the best tool and fixture, and it can calculate cost and time.

Flexible Machining Systems (FMS) are extensions of group technology and cellular manufacturing concepts. Using integrated CAD/CAM, parts can be designed and programmed in half the time it would normally take to do the engineering. The part programs can be downloaded to a CNC machining center under the control of an FMS host computer. The FMS host can schedule the CNC and the parts needed to perform the work.

Computer integrated manufacturing can include different combinations of the tools listed above.

Issues involved in CIM

One of the key issues regarding CIM is equipment incompatibility and difficulty of integration of protocols. Integrating different brand equipment controllers with robots, conveyors and supervisory controllers is a time-consuming task with a lot of pitfalls. Quite often, the large investment and time required for software, hardware, communications, and integration cannot be financially justified easily.

Another key issue is data integrity. Machines react clumsily to bad data, and the costs of data upkeep as well as general information systems departmental costs is higher than in a non-CIM facility.

Another issue is the attempt to program extensive logic to produce schedules and optimize part sequence. There is no substitute for the human mind in reacting to a dynamic day-to-day manufacturing schedule and changing priorities.

Just like anything else, computer integrated manufacturing is no panacea, nor should it be embraced as a religion. It is an operational tool that, if implemented properly, will provide a new dimension to competing: quickly introducing new customized high quality products and delivering them with unprecedented lead times, swift decisions, and manufacturing products with high velocity.

4.4 Facilities Layout

The Facility Layout plan institutionalizes the fundamental organizational structure. Every layout has four fundamental elements:

1. Space Planning Units (SPUs)
2. Affinities

Notes

3. Space
4. Constraints

Keeping these in mind, several fundamental choices are available to managers. These choices are incorporated in the four basic types of layouts:

1. Process layout
2. Product layout
3. Fixed layout
4. Group layout

These basic types of layout should keep in mind the following principles:

1. The emphasis should be on gross material flow, personal space and communication.
2. Socio-technical considerations should play an important part in determining the layout.
3. The layout should facilitate arrangement of physical facilities, which allows most efficient use of men, machines and materials necessary for the operation to meet the requirements of capacity and quality.
4. The layout should be based on the premise that a properly designed facility is an important source of competitive advantage.

It is very difficult to enumerate all the properties of a layout that makes the most efficient use of men, machines and materials; however the layout should try to:

1. Operate at low cost
2. Effectively use space
3. Provide for easy supervision
4. Provide fast delivery
5. Minimum cost of material handling
6. Accommodate frequent new products
7. Produce many varied products
8. Produce high or low volume products
9. Produce at the highest quality level
10. Worker's convenience and safety
11. Provide unique services or features

Though it is not possible to simultaneously optimize all these factors in the design, a balance should be maintained. The functional layout for each building, structure or other sub-unit of the site whether in terms of space allocation or capacity from the Operations Department's point of view is perhaps the most important level of planning.

4.5 Repetitive Process Layout

Process layout is also known as functional layout. Similar machines or similar operations are located at one place as per the functions. For example, as will be apparent from Figure 4.2, all milling operations are carried out at one place while all lathes are kept at a separate location. Grinding, milling or finishing operations are carried out in separate locations. This functional grouping of facilities is useful for job production and non-repetitive manufacturing environment.

4.5.1 Process Layout and Material Handling Costs

Notes

In process layouts, one of the principles of paramount importance is that centers between which frequent trips or interactions are required should be placed close to one another.

This has implications in all manner of organizations; in a manufacturing plant, it minimizes materials handling costs; in a warehouse, stock picking costs can be reduced by storing items typically needed for the same order next one another; in a retail store, minimizing customer search and travel time improves customer convenience; in an office where people or departments must interact frequently are located near one another – both communication and cooperation often improve and coordination between departments can be less challenging.

There are both quantitative and semi-quantitative methods available for process layouts. Load-Distance Model is a simple mathematical model that captures costs to identify a location that minimizes the total weighted loads moving into and out of the facility. Another popular technique similar to the Load Distance Model for plant layout is the Travel Chart Technique. In this, we start from an initial layout, which may be the existing layout. The designer concentrates only on the critical points of the layout. Critical points are generally the areas, which have high volume-distance movement of materials. The designer attempts to modify the layout so that there is maximum improvement in the critical points.

Spiral Analysis

In certain types of layout problems, numerical flow of items between departments is either impractical to obtain or does not reveal the qualitative factors that may be crucial to the placement decision. In these situations, a semi quantitative technique like the Spiral Analysis can be used.

Spiral Analysis involves:

1. Developing a relationship chart showing the degree of importance of having each department located adjacent to every other department.
2. From this chart, an activity relationship diagram, similar to the flow graph is obtained, and is used for illustrating material handling between departments.

The objective of the spiral analysis is to arrange the departments in such a manner that the transportation costs of material handling are minimized. The analysis tries to find an option that provides the most direct flow of material between different departments.

Anand Parvat Industries plans to redesign the layout of its factory. The factory produces five major products. The initial layout plan is shown in Figure 4.2. In addition to incoming and outgoing stores, the factory has 6 departments. This data with the flow paths and volume for the different products is captured in Table 4.1.

Table 4.1: Sequence of Processing Departments

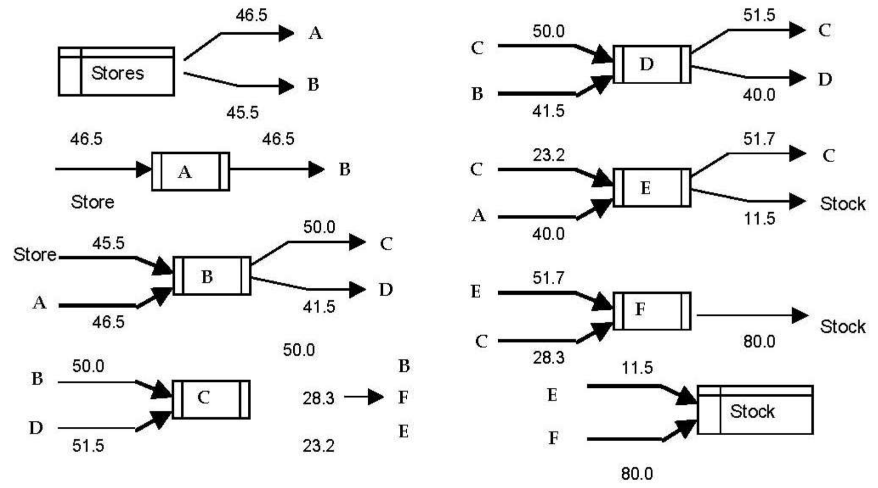
Product group	Percentage volume	Flow path through departments
I.	18.2	Stores, A,B,C,D,E,F, Stock
II.	10.9	Stores, B,D,E,F, Stock
III.	29.3	Stores, A,B,D,C,F, Stock
IV.	24.2	Stores, B,C,D,C,E,F, Stock
V.	8.9	Stores, B,C,D,F, Stock
TOTAL	91.5	

Notes

In the table, the first column represents a product or a group of products. The second column represents the volume the product or the product group constitutes of the total flow in the layout. The third column shows the sequence of departments through which the product passes. For example, Product 'I' will go to the lathe department, from there it will go to shaping, then drilling, milling, grinding and finally to the Inspection Department before the product is stocked (refer Figure 4.3). The second column represents the percentage volume of the product group.

The total percentage volume of all the product groups will always be less than or equal to 100 per cent. In the example, it is less than 100 per cent. In order to simplify the problem, similar to ABC analysis of inventory systems, products that do not have significant effect on the total production pattern, have not been shown in Table 4.1. However, care must be taken to ensure all significant products and product groups are included.

Figure 4.3: Schematic Representation of Material Flow



The input-output information on all the departments is computed and reflected in a schematic diagram. This is called the Material Flow Diagram. The schematic material flow diagram for our example is shown as Figure 4.4. The steps involved in creating the material flow diagram in the Spiral Method are:

1. Draw a circle to represent each department or activity area.
2. On the left side of the circle draw a line to represent incoming material from each activity, which immediately precedes the activity of interest for any product group.
3. On each line to the circle indicate the quantity or per cent of total activity between the two sequence steps.
4. At the right of the circle draw a connecting line that denotes where the material has to go when the operation has been completed.
5. These lines tell us the quantity or percentage of total activity represented by the completed material.

These five steps give schematic representation of various departments and their material inflow and outflow. Remember, totals have to tally. For example, take the store figures. The total that leaves the store has to equal 91.5, the figure given in Table 4.1. Similarly, the total reaching 'stock' will also be 91.5. You also have to ensure that inputs and outs are balanced for each activity or department.

Notes

Space requirements also need to be computed. Based on the size and number of machines to be installed and the space available for the layout, the minimum space required is worked out. The requirement of space for each department, for Anand Parvat Industries, is shown in Table 4.2.

Table 4.2: Area Required by Different Departments

Department	Area required in sq. ft.
A - Turning Department (Lathes)	1000
B - Shaping Department	900
C - Drilling Department	650
D - Milling Department	750
E - Grinding Department	1100
F - Inspection Department	1200
Store - Incoming	1200
Store - Finished Stock	1200
Total	8000

The spiral method works under following assumptions:

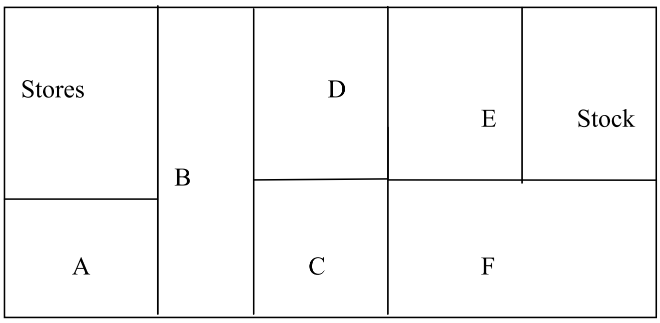
1. The department shape is a combination of square and rectangles.
2. The area of a department varies only slightly with peripheral changes in its shape.

The solution is arrived at by trial and error. The following steps are taken:

1. The activity area is located. Each activity is located in such a manner that the serviced area and servicing areas are located with a common periphery.
2. Around each of the service activity areas arrange their subsequent servicing or serviced areas, again maintaining necessary areas assignment for each.

This process is continued until all departments have been located. Using this schematic, the departments should be so arranged that a department has at least some common boundary with each of the departments from which it receives material or to which it delivers material. This will ensure that material from a department is moved to another department with minimum cost. This is a trial and error procedure. It does not guarantee that an optimal solution will be obtained. Also, the solution may not be unique. One of the possible arrangements by this method for our example is shown in Figure 4.4.

Figure 4.4: A Feasible Arrangement by using the Spiral Method



Notes

Computerized Relative Allocation of Facilities Technique (CRAFT)

A number of computerized layout programs have been developed since the 1970s to help devise good process layouts. One such program that is widely applied is the Computerized Relative Allocation of Facilities Technique (CRAFT). The CRAFT method also follows the same basic idea as the 'Travel Chart Technique', but with some operational differences. It requires a load matrix and a distance matrix as initial inputs, but in addition, it also requires a cost to be computed per unit distance traveled, say, ₹ 1.50 per meter moved.

With these inputs and an initial layout in the program, CRAFT tries to improve the relative placement of the departments as measured by total material handling cost for the layout. The relationship that it uses is similar to the Load Distance Model:

Material handling cost between departments = Number of loads × Rectilinear distance between department centroids × Cost per unit distance.

The program simulates different arrangements of layout and then makes improvements by exchanging pairs of departments iteratively until no further cost reductions are possible.

4.5.2 Advantages and Disadvantages of Process Layout

Process Layout is best suited for non-standardized products; where there is a low volume, high variety manufacturing environment; where the market requires frequent change in product design; in job-shop manufacturing; and for setups where very expensive or specialized machines like CNC milling, coordinate measuring machine etc., are required to be used. Its advantages are:

1. Initial investment in process layout is low.
2. Varied degree of machine utilization may be achieved in process layout, as machines are not dedicated to any single product.
3. There is greater flexibility and scope of expansion.
4. High product variety can be easily handled, therefore different product designs and varying production volumes can be easily adopted.
5. The overhead cost is low.
6. Breakdown of one machine does not result in total stoppage of production. Maintenance of machines is relatively easy as it can be scheduled without greatly impacting production.
7. Easy, effective and specialized supervision of each function area is easy to achieve. With different departments for different processes, better teamwork can be achieved.
8. There is low setup and maintenance cost compared to other layouts.

Though the advantages outweigh the disadvantages in job shops and batch production, there are some disadvantages of Process Layout:

1. There is high degree of material handling. Parts may have to backtrack in the same department.
2. Large work in process inventory is common. This may lead to more storage area.
3. Workers are more skilled. This is because of variety in products and difference in design, therefore, labour cost is higher.
4. Total cycle time is high. This is due to waiting in different departments and longer material flow.

Notes

5. Inspection is more frequent which result in higher supervision cost.

6. It is difficult to fix responsibility for a defect or quality problem. The work moves in different departments in which the machine preference is not fixed. Therefore, which machine or which operator was faulty during a quality lapse may be difficult to trace in some cases.

7. The production planning and control is relatively difficult.

With the changing perceptions of consumers, many feel that process layout is best limited to cases where the volumes are so low and the differences between products are so great that line flow processes, batching, and cellular manufacturing are not feasible.

4.6 Repetitive Product or Line Layout and its Design

A product layout is also called a line layout. In this type of arrangement, the various facilities, such as machine, equipment, work force, etc., are located based on the sequence of operation on parts. Where the facility is needed again after few other operations, the facility is duplicated as required by the sequence of operations.

Product layout is used for continuous operations, where the part variety is less, production volume is high and part demand is relatively stable.

Case Study

Ford's Assembly Line

Though Ransom E. Olds created the first assembly line in 1901, Henry Ford is recognized for revolutionizing industry by mass-producing automobiles. Ford improved upon Olds' assembly line idea by installing conveyor belts and converting Olds' idea into a moving assembly line. According to Ford, he developed the idea by watching the sequence of operations in a meat factory. By using a moving assembly line, Ford was able to cut the time of manufacturing a Model T from a day and a half to a mere ninety minutes. The assembly line concept has remained more or less similar since 1913.

The assembly line concept is applicable on products that can be produced with identical parts. Since each part is identical and can be replaced with an identical part, the entire production sequence can be predetermined in careful detail. This permits each task to be minutely studied by engineers and managers to find ways to make the sequence quicker and cheaper.

Question

What was different in Ford's approach? What were its advantages?

Using better work methods, specialized equipment and tools, and extensive employee training the speed of producing the product can be increased and the cost decreased. This is the basic concept of the assembly line.

Notes

4.6.1 Defining the Layout Problem

The layout-planning problem for assembly lines is to determine the minimum number of stations (workers) and assign tasks to each station, so that a desired level of output is achieved. The design must consider the following aspects:

1. It should focus on achieving a desired level of output capacity.
2. The tasks assigned to stations and the sequence in which tasks must be carried out.
3. The output should be attained efficiently, without using minimum input resources.

Table 4.3: Assembly Line for Contact Breaker

Work Station	Preceding Work Station	Task Assigned	Predecessor Task	Task Time/Unit (Hours)	Operators per station
1	-	A: Contact Breaker Assembly; Take Molding Half and clean burrs etc.	None	0.010	1
2	1	B: Install contacts C: Install Springs D: Install plastic levers etc. on Molding Half.	A B A,C	0.020 0.020 0.040	2
3	1	E: Install contacts F: Install Springs G: Install plastic levers etc., on Molding Half.	A B A,C	0.020 0.020 0.040	2
4	2,3	H: Close with other Molding Half	G	0.050	2
5	4	I: Assemble 4 of the above units	H	0.008	1
6	5	J: Insert Rivets	I	0.040	1
7	6	K: Rivet the sandwich units	J	0.098	1
8	7	L: Switching Test under load	E	0.050	1
9	8	M: Pack Contact Breaker unit	F	0.020	1
	Total			0. 354	

How this is achieved can be best understood with an example. ABC Electricals is a medium-sized firm in Delhi. It has an established design of a contact breaker assembly, used industry-wide to protect all electrical circuits. The company has established an assembly line to manufacture the product.

The operator starts the assembly process with a molding half. Into this molding he puts the contacts, springs, plastic levers, etc. The assembly is closed off with a similar molding half. The final assembly, comprised up to four of these units, is secured with four rivets passing through the sandwich. The assembly is then tested. Testing is a critical operation, as the contact breaker assembly carries up to 415 volts. If the unit is found acceptable, it is labeled and packed for dispatch.

The method of assembly was on a series of benches with the sub-assemblies being placed in boxes for transfer to the riveting press. The rivet operation involved the manual placing of four long tubular rivets, pressing a 5 tonne press and securing the assembly. The product was again boxed for transfer to testing.

The demand for this was 3000 units per month. However, due to the high rate of rejection and the highly labour intensive process, they were unable to meet the demand. Table 4.3 gives the assembly line details for the product.

Is capacity adequate? The number of units this layout permits the company to produce each day depends on the station whose tasks take the longest time to perform. From Table 4.3 we know that:

1. The task assigned to station1 requires 0.010 hours,
2. Station 2 and station 3 are parallel paths and the tasks assigned take 0.080 hours,
3. Station 4 requires 0.50 hours,
4. The longest time is needed at station 6 that is 0.098 hours, and so on.

Since every unit passes through all stations, station 3 is the bottleneck operation. This station restricts the rate of flow of the line. With this layout, a finished contact breaker will flow to the end of the line every 0.098 hours. This time is called the cycle time of the line.

The cycle time is, in fact, also the time after which the conveyor moves in a moving assembly line. Cycle time is defined as the time period after which completed units come off the assembly line. Completed units are available after each movement of the conveyor, as the basic structure worked upon at the last workstation will become a completed unit in that time.

With a cycle time of 0.098 hours, how many contact breakers are produced daily? If the operation runs for one 8-hour shift each day, the available productive time each day is 8 hours. Therefore, maximum daily output can be as follows:

Maximum daily output = Available time/(Cycle time/unit)

= 8.0/0.098 = 81.63 units

Since this assembly line can generate 81 units daily, and the requirement is 3000 units per month, capacity is inadequate,

An alternative method for determining whether capacity is adequate is to calculate the maximum allowable cycle time give a desired capacity 3000 units/month.

Maximum allowable cycle time = Time available/Desired number of units

= (8 × 24)/3000 = 0.064 hours/unit

This calculation shows that a layout whose cycle time is 0.064 hours or less will yield the desired capacity.

Is the sequence of tasks feasible? For now, we will assume that the proposed sequence of tasks is feasible. By examining the product, we can see the sequence restrictions that must be observed in its assembly.

Example: The moldings have to be assembled prior to subsequent assembly steps to ensure that the four moldings can be connected together.

Finally, the contact breaker cannot be assembled until the moldings have been riveted together.

Notes

This sequence must be observed because the contact breaker cannot be assembled correctly in any other way. On the other hand, it makes no difference whether the contacts are placed before the plastic lever or after the springs are assembled in the molding. Similarly, the order of the riveting is irrelevant.

In general, the assembly tasks, listed in the table, are broken down into the smallest whole activity. For each task, we note in column 4 of Table 4.3, the task or tasks that must immediately precede it. However, job simplification is possible even within the requirement of precedence.

Is the Line Efficient? The revised layout had six stations manned by 12 operators. All workers are paid for 8 hours daily. How much of their time was spent productively? This assignment to revise the layout was given to Technology and Management Systems (TAMS).

ABC Electricals, due to the traditional approach, believed that the assembly was very labour intensive. Even with parallel processing they were utilizing up to twelve operators as is shown in column 6 of Table 4.3. TAMS decided to balance the assembly line.

4.6.2 Assembly Line Balancing

Given a capacity or production rate requirement, we can meet that requirement with a single line with a cycle time 'c', or with two parallel lines with a cycle time '2c', and so forth. Line balancing programs have been developed that enable the most efficient use of the assembly line.

In multiple parallel lines, as the number of parallel lines increases, so does the scope of job. We can also increase output by horizontal job enlargement, as has been demonstrated in the example of ABC Electricals. The point is that alternatives do exist.

How can the cost of idle time of man and machine be reduced? Perhaps the ten tasks (A to M in Table 4.3 - exclude tasks either at station 1 or station 2) can be reassigned so that more available employee time is used.

An ideal assembly line would be one where tasks are assigned to different workstations in such a way that the total processing times at each workstation is equal. If every station used up an equal amount of task time, no time would be idle time. Though this is seldom true, an approximation of this condition can be achieved by effective assembly line balancing. The problem of equalizing stations is solved using six steps:

1. Define tasks.
2. Identify precedence requirements.
3. Calculate the minimum number of work stations required to produce desired output.
4. Apply an assignment heuristic to assign tasks to each station.
5. Evaluate effectiveness and efficiency.
6. Seek further improvement.

For the example of the contact breaker facility, we have already taken the first step, defining tasks, shown in Table 4.3. The second step requires identifying a specific sequence. These sequence requirements are also listed in Table 4.3 in column 4.

Once the desired output is specified, we can calculate the theoretical minimum number of stations required. This is done by contrasting the time required to produce one unit with the time we can allow, given the daily output requirements. We have already calculated the time required, as the sum of the task times in Table 4.3 and we have calculated the time allowable, as the maximum allowable cycle time.

Since just 0.098 hours are allowed to produce one unit, 5.56 stations must operate simultaneously, each contributing 0.098 hours, so that the required 0.356 hours are made available.

Theoretical minimum Number of stations = Time required/(unit time allowed/unit)

To produce 1 unit = 0.356 hours/(0.098 hours/unit) = 3.63 stations

Since only whole stations are possible, at least four stations are needed. The actual layout may use more than the minimum number of stations, depending on the precedence requirements. The initial layout in Table 4.3 uses nine stations.

The fourth step assigns tasks to each station. The designer must assign ten tasks to six or more stations. Several assignment combinations are possible. In the example given earlier, TAMS designed a system that provided a rectangular platen system manned by only five operators. All assembly was completed on the platen with the sub-assemblies being transferred to a central position on the platen for riveting.

For larger problems with thousands of tasks and hundreds of stations, we often use heuristics. We will apply a Longest Operation Time (LOT) heuristic to find a balance for the 0.098 hours/unit cycle time. The LOT steps are:

Heuristic Step 1: Longest operation time (LOT) gives the top priority of assignment to the task requiring the longest operation time. Assign first the task that takes the most time to the first station. However, the precedence requirements have to be maintained. In our example, task 'K' requires the longest operation time of 5 minutes (the bottleneck operation); therefore, this task has the highest priority of assignment at the first workstation. Table 4.4 shows that task 'K' has precedence requirement of other tasks, i.e., there is a need for other tasks to be competed for the execution of task 'K'. Therefore, task 'K' cannot be assigned to the first work-station. We have to assign task 'A' as the first task.

Heuristic Step 2: In the first rule, task 'A' is the eligible task for the first workstation and is assigned to it. As the task time of 'A' is 0.010 hours, and the bottleneck task is 0.098 hours, additional tasks can be assigned to the station. Therefore tasks 'B', 'C', and 'D' which require a total time of 0.080 hours can also be assigned to this station. The time available on station 1 after completing these tasks is 0.008 hours. As there is no other task that has this timing, no more tasks can be assigned to this station.

Heuristic Step 3: For workstation 3, we see that task 'H' requires the longest task time of 0.050 hours. From Table 4.4, notice that tasks 'I' and 'J' require 0.008 and 0.040 hours respectively. In keeping with the precedence requirement, tasks H, I and J can be assigned to workstation 3 as the total of the time required to complete these tasks is 0.098 hours.

Heuristic Step 4: Workstation 4 is the bottleneck station. The task 'K' cannot be split into parts, this task has to be assigned to a workstation and the cycle time cannot be less than the duration of this task. No other task can be accommodated at this workstation

Heuristic Steps 5-7: Repeat the above-explained process to get Table 4.4. Note that we have used five workstations for the assignment of all the tasks. It could have been more; for example if task 'I' required more time, we would have ended up with 6 workstations. This explains why this is called the theoretical minimum workstations.

This entire process, carried to completion, is summarized in Table 4.4, showing a five-station assembly line comprising 10 tasks.

This layout is effective if it yields the desired capacity. It is efficient if it minimizes idle time. Though the new assembly line design does increase the efficiency, as the idle time is significantly reduced, it still does not yield the desired capacity. To be able to meet the demand of ABC Electricals, in the example we have been following, we need to reduce the cycle time to 0.064 hours.

Notes

There are occasions when effectiveness and efficiency can be increased by deviating from procedures. For example, we can look at task sharing i.e., when more than one workstation is manned by one worker. This can reduce idleness as we are eliminating workers, and letting the others take turns at a workstation: other improvements are possible if more than one worker can be assigned to a single station, as was done by ABC Electricals earlier as shown in Table 4.4. Finally, if the desired output does not exceed the required capacity, bottlenecks may be reexamined.

Table 4.4: Line Balancing Problem

Work Station	Preceding Work Station	Task Assigned	Predecessor Task	Task Time/Unit (Hours)	Operators per station
1	-	A: Contact Breaker Assembly; Take Molding Half and clean burrs etc.	None	0.010	1
2	1	B: Install contacts C: Install Springs D: Install plastic levers etc. on Molding Half.	A B A,C	0.020 0.020 0.040	2
3	1	E: Install contacts F: Install Springs G: Install plastic levers etc., on Molding Half.	A B A,C	0.020 0.020 0.040	2
4	2,3	H: Close with other Molding Half	G	0.050	2
5	4	I: Assemble 4 of the above units	H	0.008	1
6	5	J: Insert Rivets	I	0.040	1
7	6	K: Rivet the sandwich units	J	0.098	1
8	7	L: Switching Test under load	E	0.050	1
9	8	M: Pack Contact Breaker unit	F	0.020	1
	Total			0. 354	

In the example of ABC Electricals, TAMS looked at the bottleneck operation to see how it could be improved. Initially riveting (the bottleneck operation) took place using a 5 tonnes press, which completed the riveting in two passes. It had a rotating fixture that permitted riveting of two rivets simultaneously. The rotating fixture was removed and a die was designed so that riveting required just one pass. Testing took place immediately following riveting. Consecutive test failures were flagged up immediately allowing corrections to be made without a backlog of test failures. All acceptable products were then immediately laser marked with the company logo and specification. Finally, the product was unloaded to a multilane conveyor to packing.

With the change in the bottleneck, the assembly line was redesigned using the LOT technique. As you can see, the newly designed assembly line had seven stations with 7 operators. This meant that there was an increase in the number of stations and workers. It was less efficient than the layout suggested earlier.

Notes

However, though less efficient, the new system was able to reduce the cycle time 0.060 hours i.e., the output had increased from 1960 units per month to 3200 units per month. This gave ABC Electricals the number of assembled Contact Breakers units they required. It also pruned the excessive costs so that ABC Electricals would eventually be more competitive.

Very often, better results are obtained when the organization is effective rather than when it is efficient. Being more effective it reduced the costs of the product and ABC Electricals, the additional and unnecessary costs were not passed on to the customers. The form of the final assembly line is shown in Table 4.5.

Table 4.5: Final Assembly Line Design

Work Station	Preceding Work Station	Task Assigned	Predecessor Task	Task Time/Unit (Hours)	Operators per station
1	-	A: Contact Breaker Assembly; Take Molding Half and clean burrs etc. B: Install contacts C: Install Springs	None A B A,C	0.010 0.020 0.020	1
2	1	D: Install plastic levers etc. on Molding Half.	A	0.040	1
3	2	H: Close with other Molding Half	G	0.050	1
4	3	I: Assemble 4 of the above units J: Insert Rivets	H I	0.008 0.040	1
5	4	K: Rivet the sandwich units	J	0.060	1
6	5	L: Switching Test under load	E	0.050	1
7	6	M: Pack Contact Breaker unit	F	0.020	1
	Total			0. 354	

Many other heuristics may be used instead of the Longest Operation Time (LOT) approach. Several computerized heuristics are available, and since different heuristics can lead to different layouts, it may be worthwhile to want to try more than one approach. Mathematical and computer-based Heuristic models can identify and evaluate alternative layouts far more rapidly than manual or intuitive methods. Though these models use observation and experimentation as they do theory, they have their limitations.

4.6.3 Graphic and Schematic Analysis

Historically, assembly line layouts have used manual trial-and-error techniques and templates, drawings, and graphical procedures. For large facilities with many tasks and work centers, mathematical procedures are extremely complex and there is no guarantee that will ensure finding the best possible design. The quality of the design very often depends upon the experience and judgment of the designers and the industrial engineers.

Notes

4.6.4 Limitations of Product Layout

The widespread use of assembly-line methods both in manufacturing and in the service industry has dramatically increased output rates. Historically, the focus has almost always been on full utilization of human labour, i.e., to design assembly lines minimizing human idle time. However, there have been questions raised if this is the best approach. The example of ABC Electricals, demonstrates this.

Though research has tried to find optimal solutions to product layout system, some of the basic limitations of the system are identified below:

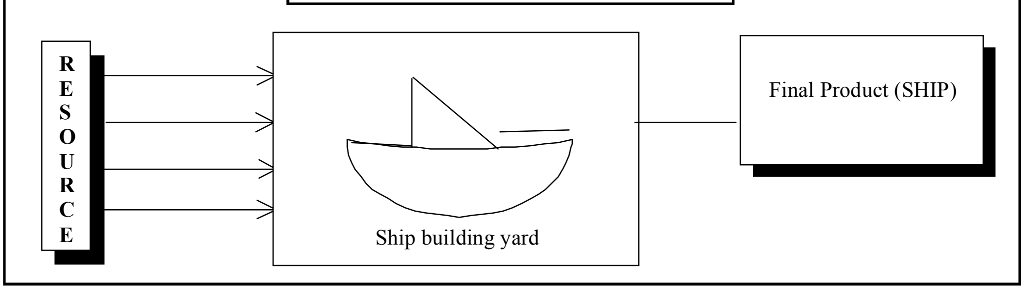
1. Layouts are relatively fixed and changes in product design are difficult to accommodate.
2. Product variety is very much limited.
3. Breakdown of a particular machine in a production line halts the production output of the entire line.
4. Capital investment in machines is often higher as compared to process layout and duplication of machines in the line is part of this cost.
5. There is limited flexibility to increase the production capacities.

Task Find out more about assembly line balancing. Find more information about the evolution of this concept.

4.7 Fixed Position Layout

In this type, the material remains at a fixed position and tools, machinery and men are brought to the location of the material. Fixed Position Layout is essential when the products are difficult to move. Need for such type of layouts arises in case of extremely large and heavy products. Some of the examples are production of aircraft, ships, dams, bridges, and housing industry.

Figure 4.5: Fixed Layout



The advantages of this layout are:

1. This layout is flexible with regard to change in design, operation sequence, labour availability, etc.
2. It is essential in large project jobs, such as construction and shipbuilding etc., where large capacity mobile equipment is required.
3. Very cost effective when similar type products are being processed, each at a different stage of progress.

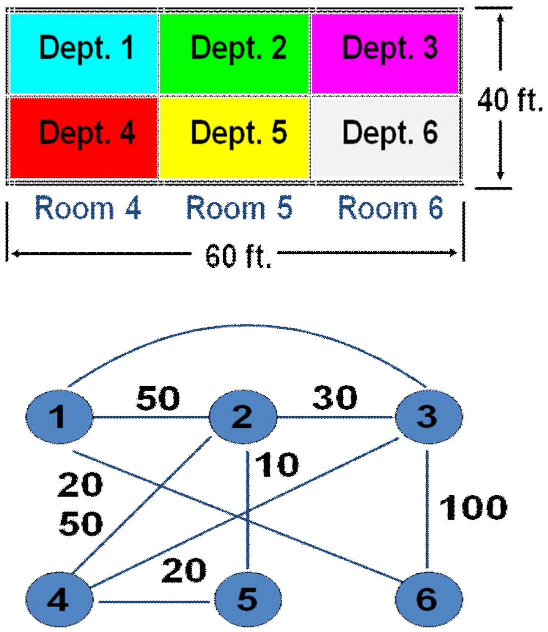
Notes

The limitations of fixed position layout are as follows:

1. Capital investment may be for a one-off product, which can make it expensive.
2. Due to long duration to complete a product, average utilization of capital equipment is limited.
3. Space requirements for storage of material and equipment are generally large.

Products essentially require high class planning and focused attention on critical activities to maximize margins.

Example: You work in facilities engineering. You want to find the cost of this layout. The cost of moving 1 load between adjacent dept. is $1. The cost between nonadjacent dept. is $2.

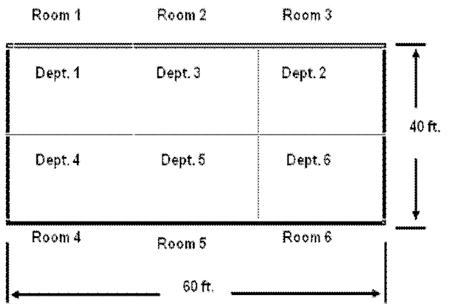


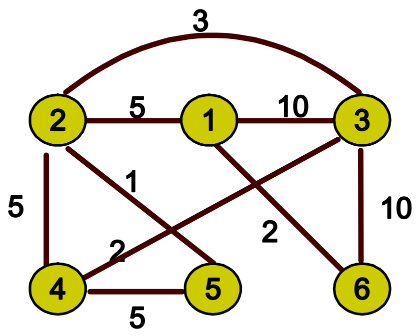
Dept.	Dept.	Cost
1	3	$200
1	2	$ 50
1	6	$ 40
4	2	$ 50
4	3	$ 40
4	5	$ 50
2	5	$ 10
2	3	$ 30
3	6	$100

Solution: In above table total cost is $ 570

Can we get a layout cheaper than $570? There are 6! Or 720 possibilities. Putting departments 1 & 3 adjacent to each other gives a total cost of $480.

Notes





Dept.	Dept.	Cost
1	2	$ 50
1	3	$ 100
1	6	$ 20
4	2	$ 50
4	3	$ 40
4	5	$ 50
2	5	$ 10
2	3	$ 60
3	6	$ 100
Total cost		$ 480

4.8 Cellular or Group Layout

When TI Cycles reorganized its manufacturing plant, it used Group or Cellular Layout to improve the efficiency of production. Sundaram Fasteners boasts of a Cellular Layout with world-class control on manufacturing costs. What, then, is Cellular Layout? It is a layout based on group technology principles. It is a combination of both process and product layout and incorporates the strong points of both of these. Conventional layouts, product and process layouts, are two extremes of the spectrum. The specific approach used to reach a group layout may also result in one of the above two extremes, if the situation so demands.

This layout is suitable when a large variety of products are needed in small volumes (or batches). The group technology principle suggests that parts which are similar in design or manufacturing operations are grouped into one family, called a part-family. For each part-family, a dedicated cluster of machines (called 'machine cells') are identified. Generally, all the processing requirements of a particular part-family are completed in its corresponding machine cell, eliminating inter-cell transfers of the part.

Group technology and Cellular Layouts can be combined and used to produce families of parts more economically than can traditional process or product layouts. Data is gathered to identify parts with similar characteristics, which are also manufactured similarly. Groups of items can be formed either according to similarities in their design (external features such as size, shape, use, etc.) or according to similarities in their manufacturing process. This is a time-consuming and tedious task, which can be accomplished by the following methods:

1. Visual inspection method (for grouping items according to design similarities), which is very simple in application but not very accurate.

2. Examination of design and production data (for grouping items according to design similarities), which is more complex to implement than visual inspection but much more accurate.

Notes

3. Analysis of the production flow of items (for grouping items according to manufacturing process similarities).

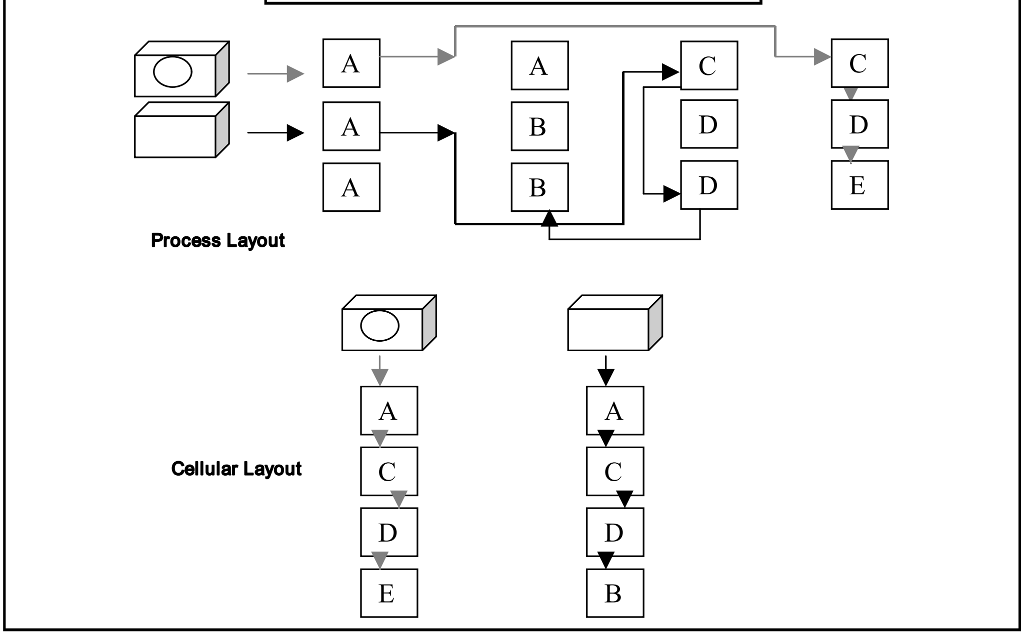
This identification and coding is the chart of group technology. The equipment to make these is grouped together and designated for these parts. To some extent, a process layout, characteristic of job shops, is changed to a small well-defined product layout. This group of equipment is called a cell, and the arrangement of cells is called a Cellular Layout.

Figure 4.6 illustrates the difference between the two alternative layouts. Two parts require different tooling;

1. One part could be made in a job shop moving from machine A - C to D - E.
2. The second part can be made moving from machine A - C to D - B.

In the Process Layout, the machines are grouped together and the product moves to the machines. In the Cellular Layout, the machines are grouped in a line flow.

Figure 4.6: Process versus Cellular Layouts



In order for a cell to be economical and practical in the long term, the machines must be closely grouped, and the cell must be flexible in its mix of capacity and must be big enough so any absent employee does not shut it down, yet is small enough for employees to identify with the cell and understand the products and equipment.

Cell manufacturing is also the building block of Flexible Manufacturing Systems (FMS). It is, in essence, FMS with some manual operations. The Cellular Layout principles are adopted in FMS because the concepts make it easier to process large volumes of information because of the decomposed manufacturing system; it is easier to manage the operational facilities compared to functional manufacturing due to limitation on cell size, and the technological compulsions often require grouping some operations like forging machines and heat treatment unit.

Although Cellular Layout is a catchy new term, the phenomenon itself is not new. For decades, large job shops have grouped equipment for high-volume parts or special customers. Similarly, assembly lines may group machines by type to make or modify a variety of parts that 'feed into' the main assembly line.

Notes

Example: Telco, Jamshedpur, has different machine shops and dye shops whose output is finally fed into the assembly line.

When considering a new technique such as Cellular Layout, managers need to thoroughly look at past practices as a guide to changing the manufacturing environment.

The U-shaped assembly line: At any airport, it is common to see baggage in the arrival area being distributed using U-shaped conveyor belts. There is a trend to move from traditional longitudinal assembly lines to U-shaped assembly lines, especially in Cellular Layouts. Not only is it useful particularly when there is a single worker in the line taking care of all the work-stations, but it also consumes less space. The U shape of the line cuts the walking distance of the worker by almost half.

Assembly line balances frequently result in unequal work-station times. Flexible line layouts, such as the U-shaped line with work sharing, could help resolve the imbalance and are a common way of dealing with this problem. The closeness of the work-stations, is used by the Japanese, to allow workers to help a fellow worker catch up, thus increasing teamwork among workers. U-shaped assembly lines are being successfully used by Matsushita Electric Co. of Japan by using a single worker in the line. In addition, the U-shaped line reduces material handling as the entry and exit points of the material on the line are nearby. A trolley which brings the raw material for the line may take back the finished goods in a single round.

Caselet

Manufacturing: Toyota Style

Toyota's 'lean production' system is a part of the generic system of 'Cellular Manufacturing'. The 'Toyota Production System' called 'lean production' by some, has been heralded by many commentators as the future for competitive manufacturing. It is a team concept and incorporates a philosophy of constantly reducing production costs through the progressive elimination of waste. This waste is seen everywhere in the manufacturing operation, and includes excessive work or 'over-production'. This has given rise to the just-in time system (JIT).

JIT is a simple principle that includes 'produce and deliver finished goods just-in-time to be sold, sub-assemblies just-in-time to be assembled into finished goods, and purchased materials just-in-time to be transformed into finished parts'.

Advantages and Disadvantages

Some of the advantages of Cellular Layouts are that overall performance often increases by lowering costs and improving on-time delivery. Quality should increase as well, though that might take other interventions beyond the layout change. Other advantages are given below:

1. Lower work-in-process inventories,
2. A reduction in materials handling costs,
3. Shorter flow times in production,
4. Simplified scheduling of materials and labour,
5. Quicker set-ups and fewer tooling changes, and
6. Improved functional and visual control.

Disadvantages include the following:

1. Reduced manufacturing flexibility.
2. Unless the forecasting system in place is extremely accurate, it also has the potential to increase machine downtime (since machines are dedicated to cells and may not be used all the time).
3. There is also the risk that the Cells that may become out-of-date as products and processes change, and the disruption and cost of changing to cells can be significant.
4. There is increased operator responsibility, and therefore behavioural aspects of management become crucial.

4.9 Combination Layout

With increasing pressure on manufacturing flexibility to meet customer needs, there has been a move towards new forms of assembly lines, e.g., mixed model lines. A mixed-model line produces several items belonging to the same family, such as the different models of cars manufactured by Maruti Udyog Ltd. In contrast, a single-model line produces one model with no variations; mixed-model production enables a plant to achieve both high-volume production and product variety.

This approach is also used by JIT manufacturers such as Toyota; its objective is to meet the demand for a variety of products and to avoid building high inventories. Mixed-model balancing is carried out by Toyota Motor Corporation by averaging the production per day in the monthly production schedule classified by specifications, and dividing by the number of working days. The production sequence during each day, the cycle time of each different specification vehicle is calculated. To have all specification vehicles appear at their own cycle time, different specification vehicles are ordered to follow each other.

This does complicate scheduling and increase the need for good communication about the specific parts to be produced at each station. Care must be taken to alternate models so as not to overload some stations for too long. Despite these difficulties, the mixed-model line may be the only reasonable choice when product plants call for many customers' options, as volumes may not be high enough to justify a separate line for each model.

4.10 Other Service Layouts

Warehouse or Storage Layout

Warehousing was supposed to disappear with Lean Manufacturing. This has rarely occurred but the nature of warehousing often does change from storage-dominance to transaction dominance.

In addition, the trend to overseas sourcing has increased the need for warehousing and its importance in the supply chain.

Warehousing buffers inbound shipments from suppliers and outbound orders to customers. Customers usually order in patterns that are not compatible with the capabilities of the warehouse suppliers. The amount of storage depends on the disparity between incoming and outbound shipment patterns.

One key to effective design is the relative dominance of picking or storage activity. These two warehouse functions have opposing requirements.

Notes

Techniques that maximize space utilization tend to complicate picking and render it inefficient while large storage areas increase distance and also reduce picking efficiency. Ideal picking requires small stocks in dedicated, close locations. This works against storage efficiency. Automation of picking, storage, handling and information can compensate for these opposing requirements to a degree. However, automation is expensive to install and operate.

Retail Layouts

A well-planned retail store layout allows a retailer to maximize the sales for each square foot of the allocated selling space within the store.

Store layouts generally show the size and location of each department, any permanent structures, fixture locations and customer traffic patterns.

Each floor plan and store layout will depend on the type of products sold, the building location and how much the business can afford to put into the overall store design.

Some of the famous retail layouts are: straight floor plan, diagonal floor plan, angular floor plan, geometric floor plan and mixed floor plan.

Office Layouts

Office productivity is influenced by a number of factors, one of which is office layout. Because office layout influences the entire white-collar-employee segment of the organization, its importance to organizational productivity should never be underestimated. Office layout is based on the interrelationships among three primary factors: employees, flow of work through the various work units, and equipment.

Efficient office layout results in a number of benefits to the organization, including the following:

1. It affects how much satisfaction employees derive from their jobs.
2. It affects the impression individuals get of the organization's work areas.
3. It provides effective allocation and use of the building's floor space.
4. It provides employees with efficient, productive work areas.
5. It facilitates the expansion and/or rearrangement of work areas when the need arises.
6. It facilitates employee supervision.

4.11 Closeness Rating

After a layout is chosen and designed and activities are defined and their requirements, developed, the next step is to define the relationships between activities. This is done by relating each activity to all of the others that have been defined. The relationships are defined by a closeness rating system:

1. "A" meaning that it is absolutely necessary that the activities be next to each other;
2. "E" meaning that it is especially necessary that the activities be close to each other;
3. "I" meaning that it is important the activities be close to each other;
4. "O" meaning that ordinary closeness be maintained (meaning that it is only necessary that these activities be in the same facility);

5. "U" meaning that it is unimportant the activities be close to each other, and
6. "X" meaning that the activities should not be close to each other.

For each relationship defined, the reason(s) why a specific closeness rating was used is also noted.

4.12 Summary

- Process technology decisions relate to organizing the process flows, choosing an appropriate product-process mix, adapting the process to meet strategic objectives, and evaluating processes.
- Each process is a single activity or a group of activities that are linked together in different patterns to produce the final product. Processes need to be categorized to describe the patterns that are formed when they are linked together.
- There are many ways in which processes can be categorized. They can be categorized on the basis of their orientation, e.g., market orientation or manufacturing processes; they may also be categorized on the basis of the production methodology or customer involvement.
- A typical flexible manufacturing system can completely process the members of one or more part families on a continuing basis without human intervention.
- Flexibility in manufacturing is the ability of a manufacturing system to respond at a reasonable cost and at an appropriate speed, to planned and unanticipated changes in external and internal environments.
- Computer Integrated Manufacturing, known as CIM, is the phrase used to describe the complete automation of a manufacturing plant, with all processes functioning under computer control and digital information tying them together.
- The Facility Layout plan institutionalizes the fundamental organizational structure. Facility layout can be categorized into four major types: process layout, product or line layout, fixed layout and group layout.
- In process layouts, one of the principles of paramount importance is that centers between which frequent trips or interactions are required should be placed close to one another.
- Process Layout is best suited for non-standardized products; where there is a low volume, high variety manufacturing environment; where the market requires frequent change in product design.
- A product layout is also called a line layout. In this type of arrangement, the various facilities, such as machine, equipment, work force, etc., are located based on the sequence of operation on parts.
- An ideal assembly line would be one where tasks are assigned to different workstations in such a way that the total processing times at each workstation is equal. If every station used up an equal amount of task time, no time would be idle time.
- Fixed Position Layout is essential when the products are difficult to move. Need for such type of layouts arises in case of extremely large and heavy products.
- The group technology principle suggests that parts which are similar in design or manufacturing operations are grouped into one family, called a part-family. For each part-family, a dedicated cluster of machines (called 'machine cells') are identified.

Notes

- With increasing pressure on manufacturing flexibility to meet customer needs, there has been a move towards new forms of assembly lines, e.g., mixed model lines.
- There are a few other service layouts which are prevalent and some are fast emerging: warehouse layout, retail layout and office layout.
- After a layout is chosen and designed and activities are defined and their requirements, developed, the next step is to define the relationships between activities which is called closeness rating.

4.13 Keywords

Assembly Line: Production follows in a predetermined sequence of steps, which are continuous rather than discrete.

Batch Production: Production is in discrete parts that are repeated at regular intervals.

Cell: Self-sufficient unit in which all operations required to make components or complete products can be carried out.

Closeness Rating: Relationships between activities in a layout.

CIM: Complete automation of a manufacturing plant

CRAFT: Computerized Relative Allocation of Facilities Technique

Cycle Time: Time period after which completed units come off the assembly line.

Fixed Position Layout: Material remains fixed and tools, machinery and men are brought to the location of the material.

Flexible Manufacturing: Ability of a manufacturing system to respond at a reasonable cost and at an appropriate speed.

Group Layout: Combination of both process and product layout and incorporates the strong points of both of these.

Mixed Layout: Produces several items belonging to the same family.

Office Layout: Based on the interrelationships among employees, flow of work through the various work units, and equipment.

Part Family: Manufacturing operations grouped into one family.

Process Layout: Similar machines or similar operations are located at one place as per the functions

Product Layout: Facilities are located based on the sequence of operation on parts.

4.14 Self Assessment

State whether the following statements are true or false:

1. The stage of the process that limits capacity of the process is called a bottleneck.
2. Batch production refers to get engaged in production of large number of products in small batches.
3. Concepts of job shop and batch production are the same.

4. In India, most of the stores fully involve customers in their production and service process.
5. Manufacturing of a personal computer involves a synthetic process.
6. The words CIM and CAM can be used interchangeably.
7. A process layout supports flexibility but can limit expansion.
8. The entire layout is designed to achieve one single motive maximum capacity utilisation.
9. Out of all the layout design, process carried out on a fixed layout consumed least time.
10. Our nearby retail stores like Reliance Fresh and More are designed as per straight floor plan.

Fill in the blanks:

11. TAMS means……………….and Manufacturing Systems.
12. Generally most of the FMCG products follow…………………process.
13. The ability of a component of a manufacturing system to switch over to an alternate path is known as……………….flexibility.
14. If maximum cycle time of a layout is 8 minutes and the desired production is 4500 units, then the time available with the unit is………………..
15. The interactions between the activities within a process is defined by the…………………….

4.15 Review Questions

1. "Location and co-ordination have become the critical issues for corporations facing the challenge of globalization". Discuss.
2. "The objective of the process is to provide the maximum overall value to the customer in the product". Substantiate.
3. Processes seldom stand alone. What is the rationale behind the statement?
4. Compare the various types of categorizations of the processes.
5. What is the basic difference between 'make to order' and 'engineer to order'? Explain with examples
6. Do you appreciate the increasing involvement of customers in the production and service process? Why or why not?
7. "Flexibility relates to the ability of the system to create products capable of meeting a customer's need". Elucidate
8. Write short notes on TAMS, CRAFT, CIM and Closeness rating.
9. Compare and contrast the process and product layouts. Give figures and tables to explain the points.
10. Explain the rationale behind assembly line and balancing.
11. Define link capacity and layout. How important it is to consider the capacity of the firm while designing a layout?
12. Under what conditions does fixed layout work well? Why it is not advisable to have fixed layout for firms producing small size products?
13. Critically analyse U shaped assembly lines vis-à-vis traditional assembly lines.

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14. With the help of examples, explain the concepts of mixed line layout and retail layouts.
15. Flexible manufacturing systems try to produce products with large variability on the same set of equipments with minimal set up times. How does cellular manufacturing help in this purpose?
16. Outline and assess the factors affecting the decisions corporations might take about the location and management of key activities, such as research and development, manufacturing, sales and marketing, in the light of the statement above. How might such corporations respond to these challenges? Illustrate your answer with examples with which you are familiar.

    This question requires students to demonstrate an understanding of the potentially competing requirements of globalization to be both global and local and how they can respond to its challenges.

    Indicative Content

    Students may refer to a number of authors to illustrate key issues in the convergence—divergence debate which is central to the process of globalization.

    Some authors argue that markets are converging upon a global market and that corporations need to base their strategies on global economies of scale by selling standardized products.

    However, others argue that globalization is more complex than this, with companies facing competing pressures to be both global and local. This could involve centralizing some activities, or at least coordinating activities on a global basis, whilst responding to local requirements in other activities.

    The central role of technology in determining both the nature of markets and the strategic/ operational opportunities and constraints upon organizations could usefully be mentioned. Further, there is a debate over whether a strong home base provides the innovative conditions necessary to compete on an international basis. This could lead to some corporations moving key activities, like research and development, to a location exposed to more favourable innovative conditions within an industrial cluster.

    Illustration by reference to examples from companies with which the students are familiar is important.

Answers: Self Assessment

1. True
2. True
3. False
4. False
5. True
6. False
7. False
8. True
9. False
10. True
11. Technology
12. Make to stock
13. Routing
14. 600 hrs/ month
15. Closeness rating

4.16 Further Readings

Notes

Books

Chase, Richard B., and Eric L. Prentis, *Operations Management: A Field Rediscovered,* Journal of Management, 13, no. 2 (October 1987): 351: 366

Schonberger, Richard J., *World Class Manufacturing: The Next Decade,* New York: The Free Press, 1996

Upendra Kachru, *Production and Operations Management - Text and Cases,* Excel Books, New Delhi

Online links

rockfordconsulting.com/computer-integrated-manufacturing

ocw.mit.edu/NR/rdonlyres/Mechanical.../2.../class22_fma.pdf

wps.pearsoned.co.uk/ema_uk_he_slack.../index.html

portal.acm.org/citation.cfm?id=1141095

nitc.ac.in/nitc/bulletin/files/opt_25390_2135794126.pdf

Notes

Unit 5: Facility Location

CONTENTS

Objectives

After studying this unit, you will be able to:

- Understand need for facility location
- Explain nature of facility location
- Discuss factors affecting location selection
- Describe selection of site for the plant

- Explain procedures for location decisions
- Discuss factor rating method
- Explain centre of gravity method
- Describe least cost method

Introduction

Where will the production happen? How to choose the facility location? Is there any ideal facility location? These are the questions that arise in every manager's mind while setting up a new plant or shifting an existing plant. There are many other detailed issues related to plant location that confront a production manager. Let us study the different aspects of this decision, which is becoming increasingly important in the current context.

5.1 Need for a Facility Location Planning

Facilities location may be defined as selection of suitable location or site or place where the factory or plant or facilities to be installed, where plant will start functioning.

The development of a location strategy depends upon the type of firm being considered. Industrial location analysis decisions focus on minimising costs; retail and professional service organisations typically have a focus of maximising revenue. Warehouse location, on the other hand, may be determined by a combination of cost and speed of delivery. The objective of location strategy is to maximise the benefit of location to the firm.

Facility planning has developed, in the past decade, into a major thriving business sector and discipline. One of the major reasons for new facilities is the global economic boom that has been accompanied by an enhancement of capacity worldwide.

In addition to the global economic boom, there are several other reasons for changing or adding locations:

1. The cost or availability of labour, raw materials, and supporting resources often change. These changes in resources may spur the decision.
2. As product markets change, the geographical region of demand may shift. For example, many international companies find it desirable to change facility location to provide better service to customers.
3. Companies may split, merge, or be acquired by new owners, making facilities redundant.
4. New products may be introduced, changing the requirement and availability of resources.
5. Political, economic and legal requirements may make it more attractive to change location. Many companies are moving facilities to regions where environment or labour laws are more favourable.

Well-planned facilities enable an organization to function at its most efficient and effective level, offering real added value improvements to the organization's core business.

5.2 Nature of Location Decisions

One of the most important long-term cost and revenue decisions company makes is where to locate its operation. Location is a critical element in determining fixed and variable costs for both industrial and service firms. Depending on the product and type of production or service

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taking place, transportation costs alone can total as much as 25% of the selling price. That is one-fourth of the total revenue of a firm may be needed just to over freight expenses of the raw materials coming in and the finished product going out. Other costs that may be influenced by location include taxes, wages and raw material costs. The choice of locations can alter total production and distribution costs by as much 10%. Lowering costs by 10% of total production costs through optimum location selection may be the easiest 10% savings management ever makes.

Once an operations manager has committed an organisation to a specific location, many costs are firmly in place and difficult to reduce. For instance, if a new factory location is in a region with high energy costs, even good management with an outstanding energy strategy is starting at a disadvantage. The same is true of a good human resource strategy if labour in the selected location is expensive, ill-trained, or has a poor work ethic. Consequently, hard work to determine an optimal facility location is a good investment.

Types of Facilities

The various types of facilities are briefly described below:

Heavy Manufacturing

Heavy manufacturing facilities are primarily plants that are relatively large and require a lot of space and as a result, are expensive to construct.

Example: Automobile plants, steel mills and oil refineries.

Important factors in the location decision for plants include construction costs, modes of transportation for shipping heavy manufactured items and receiving bulk shipments of raw materials, proximity to raw materials, utilities, means of waste disposal and labour availability. Sites for manufacturing plants are normally selected where construction and land costs can be kept at a minimum and raw material sources are nearby in order to reduce transportation costs. Access to rail-roads is frequently a major factor in locating a plant. Environmental issues have increasingly become a major factor in plant location decisions. Plants can create various forms of pool pollution and traffic pollution. These plants must be located where the harm to the environment is minimised. Although proximity to customers is an important factor for some facility types, it is less so for manufacturing plants.

Light Industry

Light industry facilities are typically perceived as smaller, cleaner plants that produce electronic equipment and components, parts used in assemblies, or assembled products.

Example: Making stereos, TVs, or computers, tool and die shop, breweries, or pharmaceutical firms.

Several factors are important for light industry. Land and construction costs are not generally as crucial, because the plants tend to be smaller and require less engineering. It is not as important to be near raw materials, since they are not received in large bulk quantities, nor is storage capacity required to as great a degree. As a result, transportation costs are somewhat less important. Many parts and material suppliers fall into this category and as such, proximity to customers can be an important factor. Alternatively, many light industries ship directly to regional warehouses or distributors, making it less important to be near customers. Environmental issues are less important in light industry, since burning raw materials is not normally part of their production processes, not are there large quantities of waste. Important factors include the labour pool, especially the availability of skilled workers, the community environment, access to commercial air travel, government regulation and land use requirements.

Warehouses and Distribution Centers

Warehouses are a category of their own. Products are not manufactured or assembled within their confines, nor are they sold from them. They represent an intermediate point in the logistical inventory system where products are held in storage. Normally a warehouse is simply a building that is used to receive, handle and then ship products. They generally require only moderate environmental conditions and security and little labour, although some specialised warehouses require a more controlled environment, such as refrigeration or security for precious metals or drugs. Because of their role as intermediate points in the movement of products from the manufacturer to the customer, transportation and shipping costs are the most important factors in the location decision for warehouses. The proximity to customers can also be an important consideration, depending on the delivery requirements, including frequency of delivery required by the customer. Construction and land costs tend to be of less importance as does labour availability. Since warehouses require no raw materials, have no production processes and create no waste, factors such as proximity to raw materials, utilities and waste disposal are of almost no importance.

Retail and Service

Retail and service operations generally require the smallest and least costly facilities. Examples include such service facilities as restaurants, banks, hotels, cleaners, clinics and law offices and retail facilities such as groceries and department stores, among many others. The single most important factor for locating a service or retail facility is proximity to customers. It is usually critical that a service facility be near the customers who buy from it. Construction costs are generally less important (especially when compared with a manufacturing plant); however, land or leasing costs can be important. For retail operations, for which the saying "location is everything" is very meaningful, site costs can be very high. Other location factors that are important for heavy and light manufacturing facilities, such as proximity to raw materials, zoning, utilities, transportation and labour, are less important or not important at all for service and retail facilities.

Though factory layout is the focal point of facility design in most cases and it dominates the thinking of most managers, yet factory layout is only one of several detail levels. It is useful to think of facility planning at four levels, these are:

1. Global (Site Location)
2. Macro (Site Planning)
3. Micro (Facility and Building Layout)
4. Sub-Micro (Workstation Design)

Ideally, the design progresses from global to sub-micro in distinct, sequential phases. At the end of each phase, the design is 'frozen' by consensus. Moving in a sequential manner helps management in the following manner:

1. Settling the more global issues first.
2. It allows smooth progress without continually revisiting unresolved issues.
3. It prevents detail from overwhelming the project.

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Based on strategic importance, the macro layout is accepted to be the most critical and strategically important aspect of facility planning. However, all the stages have their own importance and significance.

Table 5.1: Facility Planning Matrix

Level	Activity	Space Planning Unit	Environment
Global	Site Location & Selection	Sites	World or Country
Macro Layout	Site Planning	Site Features, and Departments	Site and Building Concept
Micro Layout	Facility, Building and Factory Layout	Buildings, Workstations Features	Plant or Departments
Sub-Micro Layout	Workstation & Cell Design	Tool & Fixture Locations	Workstation & Cells

5.3 Factors affecting Location Decisions

5.3.1 Factors affecting Manufactured Products

Manufactured products differ from many service products as production may take place at a location, and then the goods are distributed to the customer. Often the source of raw materials is an important factor in deciding locations. Very often, you want to locate your operation close to that source of raw material.

Example: In aquaculture, the incubation of salmon eggs and the first stage lifecycle of the fish are done in fresh water. Therefore, it is advantageous to locate hatcheries where there is an abundance of fresh water.

The typical factors that require consideration are:

1. ***Location of markets:*** Locating plants and facilities near the market for a particular product or service may be of primary importance for many products in the sense that location may impact the economics of the manufacturing process. This may be because of:
   (a) Increased bulk or weight of the product
   (b) Product may be fragile.
   (c) It susceptible to spoilage.
   (d) Add to transportation costs.
   (e) Increase transit time.
   (f) Decrease deliveries.
   (g) Affect the promptness of service.
   (h) Affect the selling price of the product – the transportation cost often makes the product expensive.

   Assembly-type industries, in which raw materials are gathered together from various diverse locations and are assembled into a single unit, often tend to be located near the intended market. This becomes especially important in the case of a custom-made product, where close customer contact is essential.

2. ***Location of materials:*** Access to suppliers of raw materials, parts, supplies, tools, equipment, etc., are very often considered to be of paramount importance. The main issue here is the promptness and regularity of supply from suppliers and the level of freight costs incurred. In general, the location of materials is likely to be important if:

   (a) Transportation of materials and parts represent the major portion of unit costs.

   (b) Material is available only in a particular region.

   (c) Material is bulky in the raw state.

   (d) Material bulk can be reduced in various products and by products during processing.

   (e) Material is perishable and processing increases the shelf life.

   Keeping in mind those materials may come from a variety of locations; the plant would then be located such as to minimize the total transportation costs. Transportation costs are not simply a function of distance – they can vary depending on the specific routes as well as the specific product classifications.

Example: A Delhi-Patna consignment would be much more expensive than a Delhi-Mumbai consignment, though the distances are similar. Sea freight from an Australian port to an Indian port is comparable to the sea freight from an Australian port to an English port, though the distances are not comparable.

3. ***Transportation facilities:*** Adequate transportation facilities are essential for the economic operation of a production system. These can include – road, rail waterways airports. The bulk of all freight shipments are made by rail since it offers low costs, flexibility and speed.

   For companies that produce or buy heavy and bulky low-value-per-ton commodities as are generally involved in import and export activities, shipping and location of ports may be a factor of prime importance in the plant location decision. Truck transport for intercity transport is increasing as is airfreight and executive travel.

   Traveling expenses of management and sales personnel should also be considered in the equation.

4. ***Labour supply:*** Manpower is the most costly input in most production systems. An ample supply of labour is essential to any enterprise. The following rule of thumb is generally applied:

   (a) The area should contain four times as many permanent job applicants than the organization will require.

   (b) There should be a diversification between industry and commerce-roughly 50/50.

   Organizations often take advantage of a location with an abundant supply of workers. Labour costs and/or skills are often a very important consideration for locating a facility. The type and level of skill possessed by the workforce must also be considered. If a particular required skill is not available, then training costs may be prohibitive and the resulting level of productivity inadequate.

   In the call center business, the need of English speaking workers becomes a factor in deciding the location of your business capacity. India has come on the map for software development because it has a large number of skilled software personnel. Microsoft,

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Texas Instruments, Cisco Systems, Oracle, etc., some of the best-known names in software applications, have located facilities in India.

Many countries, like China and India, are turning out to be attractive locations for industries that require large contingents of unskilled labour.

Did u know? Hyundai Motors recently announced that India would be its hub for supply of small cars and automobile components worldwide. Companies like Nike, Reebok, etc., are setting-up supply chains in Asia and South America. Many US automobile manufacturers are moving production facilities to Mexico.

Though, this is often very appealing, you need to bear in mind that conditions can change in time. For example, while labour costs may be low in a certain geographic location now, this will change if the demand for labour grows significantly.

In considering the labour supply, the following points should be considered.

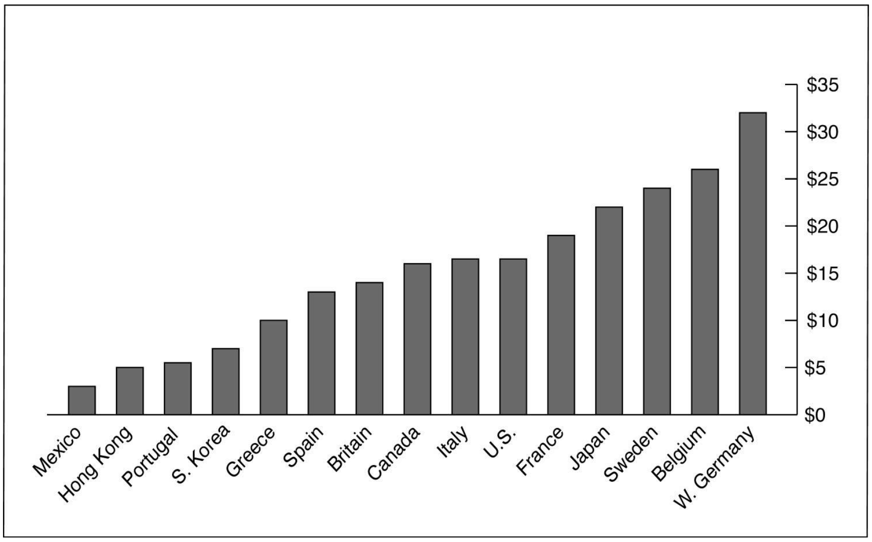
(a) Skills available – size of the labour force – productivity levels.

(b) Unionization – prevailing labour – management attitudes.

(c) History of local labour relations – turnover rates – absenteeism, etc.

Some organizations have relocated from a high skill/high cost area to a low skill/low cost area without any decrease in productivity. Sometimes it has been due to skill availability and labour-management relations but often it has been the result of higher investment in mechanization.

Notes **Labour Costs of Manufacturing Workers in Different Countries**



5. ***Location of other plants and warehouses:*** Organizations need to look at their plant locations for the complete system point of view.

(a) Distribution and supply requirements require the support of sister-plants and warehouses that complement the system.

(b) The system should be designed to minimize total system costs.

(c) The locations of competitor's plant and warehouses must also be considered (what do they know, that you don't) the object being to obtain an advantage in both freight costs and the level of customer service.

6. ***Climate:*** The recent typhoons in the Gulf of Mexico have indicated the need to look at climatic conditions as a parameter for making location decisions.

Example: Petrochemical plants near Houston were seriously threatened by Hurricane Katrina.

Japan has seismic regions that could be extremely risky for large fixed investments in products that are hazardous or dangerous or uses raw materials or produces by products that may have similar impacts.

7. ***Governmental controls and regulations:*** Table 5.2 shows the composite ranking of the business environment in 20 countries, based upon factors including government controls, regulations and incentives and labour conditions. Labour conditions include skills, availability, unionization and history of labour relations.

Table 5.2: Ranking of the Business Environment in 20 Countries, 1997-2001

1 Netherlands	11 Finland
2 Britain	12 Belgium
3 Canada	13 New Zealand
4 Singapore	14 Hong Kong
5 U.S.	15 Austria
6 Denmark	16 Australia
7 Germany	17 Norway
8 France	18 Ireland
9 Switzerland	19 Italy
10 Sweden	20 Chile

In another ranking, this time by the World Bank in their 'Doing Business in 2006' ratings, India was ranked 116 out of the 155 countries in the listing. New Zealand was number one, closely followed by Singapore. According to this report, starting a business in India requires 11 procedures and around 72 days, the highest in the Asian region. Business in India requires 20 procedures. In 'rigidity of employment' that relates to hiring and firing people, India ranks 62 on an index of 100. Around 40 procedures and 425 days are required for a contract. Also, taxes must be paid 59 times during the year.

Tax regulations, environmental regulations or various other kinds of government policies and regulations can be important factors in the location decision. There may be a more favourable investment climate in a particular geographical or political region that may attract industry to invest in that region.

5.3.2 Factors affecting Service Products

In service, the capacity to deliver the service to the customer must first be determined; only then can the service be produced. What geographic area can you realistically service?

Example: A hotel room must be available where the customer is when that customer needs it – a room available in another city is not much use to the customer.

The primary parameters on which the geographical location decisions are based for service products have been enumerated below:

1. Purchasing power of customer drawing area.
2. Service and image compatibility with demographics of the customer drawing area.
3. Competition in the area.
4. Quality of the competition.
5. Uniqueness of the firm's and competitor's locations.
6. Physical qualities of facilities and neighboring businesses.
7. Operating policies of the firm.
8. Quality of management.

Example: Karim, a speciality restaurant in Delhi, had opened outlets in the major upcoming markets in Delhi, Noida and Gurgaon. In the malls that are coming up in and around Delhi, you see well known names like Marks and Spencer, McDonald's, Tissot, Canon Nike, etc.

These are all decisions related to capacity.

5.4 Selection of Site for the Plant

When we see on the television news or read in the newspaper that a company has selected a site for a new plant, the decision can appear to be almost trivial. Usually it is reported that a particular site was selected from among two or three alternatives and a few reasons are provided such as good community or available land. However, such media reports conceal the long, detailed process for selecting a site for a major manufacturing facility.

Example: When General Motors selected Spring Hill, Tennessee, as the location for their new Saturn Plant in 1985, it culminated a selection process that required several years and the evaluation of hundreds of potential sites.

When the site selection process is initiated, the pool of potential locations for a manufacturing facility is, literally, global. Since proximity to customers is not normally an important location factor for a manufacturing plant, countries around the world become potential sites. As such, the site selection process is one of gradually and methodically narrowing down the pool of alternatives until the final location is determined. In the following discussion we identify some of the more important factors that companies consider when determining the district, region, state and site at which to locate a facility.

Notes

5.4.1 Country

Until recent years companies almost exclusively tended to locate within their national borders. This has changed somewhat in recent years as US companies began to locate outside the continental United States to take advantage of lower labour costs. This was largely an initial reaction to the competitive edge gained by overseas firms, especially Far Eastern countries, in the 1970 and 1980. US companies too quickly perceived that foreign competitors were gaining a competitive edge primarily because of lower labour costs. They failed to recognise that the real reason was often a new managerial philosophy based on quality and the reduction of all production related costs. High transportation costs for overseas shipping, the lack of skilled labour, unfavourable foreign exchange rates and changes in an unstable government have often combined to negate any potential savings in labour costs gained by locating overseas. Ironically, some German companies, such as Mercedes-Benz, are now locating plants in the United States because of lower labour costs. An overseas location is also attractive to some companies who need to be closer to their customers, especially many suppliers.

The next stage in the site selection process is to determine the part of the country or the state in which to locate the facility.

In India the Western and Central regions are generally most preferable and the Eastern region is least preferable for manufacturing facilities. This reflects a general migration of industry from the Eastern to the Western and Central regions during the last two decades primarily due to labour relations. The factors that influence in what part of the country to locate are more focused and area-specific than the general location factors for determining a country.

Caselet

P&G Planning to set up 3rd Facility in India

– by Sindhu J Bhattacharya and Virendra Verma

Following the handsome volume gains in the shampoo segment over the last few months due to price cuts, Procter & Gamble has begun thinking in terms of setting up its third manufacturing facility in the country.

At present, the company manufactures Ariel and Tide detergents at Mandideep in Madhya Pradesh and Whisper sanitary napkins and the Vicks range of products at Kundaim in Goa. However, it imports all of its shampoo brands – Head & Shoulders, Pantene and Rejoice – from overseas markets.

On whether the company was scouting for sites to set up manufacturing facility for shampoos and other products, perhaps in Himachal Pradesh, a company spokesperson said, "P&G is examining this interesting opportunity. At this stage a decision has not been made, but the Himachal Pradesh plant is being evaluated at the moment."

She confirmed that the company is importing its shampoo brands at present but did not specify whether the new facility being envisaged would manufacture shampoos.

Analysts tracking the sector said the company, which imports shampoos from Thailand and other Asean countries, has decided to invest in a new manufacturing base because of the recent volume gains in shampoos and detergents despite sluggish value growth. However, the investment earmarked for this new facility could not be ascertained.

Contd...

Notes

Said Pranav Securities' CEO, Mr Rajesh Jain, "Most shampoo marketers operate through third party contract manufacturing since it keeps costs low and also provides logistical advantages. But these advantages of third-party manufacturing are now decreasing, since places such as Himachal Pradesh offer backward area benefits as well as income tax rebates".

Another FMCG analyst felt that its own manufacturing facility will give the company further cost advantages in the segment vis-à-vis competition, particularly Hindustan Lever Ltd. (HLL)

"Besides with value added tax and MRP-based excise duties coming in next year, production outsourcing has become less attractive. P&G's move shows it has set its sights on a long innings in India," he added.

Yet another analyst said the willingness of FMCG companies to invest in building capacities showed that they were banking on the current downturn in the market to end soon. "Besides, why would companies invest unless they were sure that growth will continue even if it comes at lower price points," he wondered.

Procter & Gamble Hygiene and Health Care Ltd. (PGHH) – the listed arm of P&G - posted 30 per cent sales growth at ₹ 577.24 crore for the 12 months ended June 2004, with 35 per cent higher net profit at ₹ 92.17 crore.

While PGHH deals with Vicks and Whisper product portfolios, its subsidiary P&G Home Products caters to shampoo and detergent brands in India.

Source: thehindubusinessline.com

5.4.2 State/District

The site selection process further narrows the pool of potential locations for the facility down to several communities or localities. Many of the same location factors that are considered in selecting the country or region in which to locate are also considered at this level of the process.

Notes State/District specific factors are:

1. State/District government
2. Local business regulations
3. Environmental regulations
4. Government services (Chamber of Commerce, etc.)
5. Availability of sites
6. Financial services
7. Labour pool
8. State inducements
9. Proximity of suppliers
10. Concentration of customers
11. Taxes
12. Construction/Leasing costs
13. Land cost
14. Business climate
15. State amenities
16. Transportation system
17. Proximity of customers

5.4.3 Plant Location

The site selection process eventually narrows down to the determination of the best location within a community. In many cases a community may have only one or a few acceptable sites, so that once the community is selected the site selection is an easy decision. Alternatively, if many potential sites exist, a thorough evaluation is required of sites that are potentially very similar. For service and retail operations, customer concentrations become a very important consideration in selecting a site within a community, as does cost.

Notes Plant specific factors are:

1. Customer base
2. Construction/Leasing cost
3. Land cost
4. Site size
5. Transportation
6. Utilities
7. Land use restrictions
8. Traffic
9. Safety/Security
10. Competition
11. Area business climate
12. Income level

Task Take examples of any three manufactured products and three services firms in your city and find out why they opened their facilities in your city.

5.5 Procedures for Location Decisions

At macro level, the plans of the site are developed. These plans should include number, size, and location of buildings. It should also include infrastructure such as roads, rail, water, and energy. Planning of this stage has the greatest strategic impact on the facility planning decision. This is the time to look ahead and consider the different impacts and site and plant expansions leading to the eventual site saturation. Planning at the macro level stage should include the following:

1. Development of a facility master plan to guide facility investments over a multi-year period
2. Impact planning
3. Evaluation
4. Facility layout, space allocation, and capacity
5. Development of space standards.

5.5.1 Facility Master Plan

The facility master plan helps plan:

1. Right services: The right services consistent with the organization's mission, strategic initiatives, and market;
2. Of the right size, based on projected demand, staffing, and equipment/technology;
3. At the right location based on access, operational efficiency, and building suitability;
4. With the right financial structure.

Facility master planning strategy involves examining the existing facilities; the sizing of future facilities and site amenities; the integration of these facilities into the site; traffic flow and circulation; and the analysis of any impact that this development will have on the site with respect to environmental issues.

Notes

The areas it covers include:

1. Land-Use Planning
2. Site Evaluation
3. Zoning Analysis
4. Traffic Impact Analysis
5. Site Engineering Analysis
6. Architectural Programming
7. Needs Assessment Survey
8. Interior Space Planning
9. Adaptive Reuse Study
10. Building Design
11. Site Design
12. Landscape Design

The master planning team's work is broadly divided into two phases: Phase I deals with information gathering and analysis. Phase II addresses the synthesis of gathered information into the development of a master plan.

Steps involved in Phase I

1. A review of the development history of the business;
2. Evaluation in the local and regional context;
3. Planned current and projected conditions;
4. It starts with collecting baseline data on market dynamics, workload trends, current space allocation, and perceived facility, operational, and technology issues.

Steps involved in Phase II

1. Phase II synthesizes and integrates numerous strands of information gathered into an organized plan.
2. Orderly approach to master planning and the growth during a specified planning period.
3. The master planners, at this stage, formulate approaches to such 'big picture' issues as image, identity, character, and visions of the future of the organization within a broader, societal context.
4. The current market strategies and business plans, potential operations restructuring initiatives, and planned investments in new equipment, information technology, and other capital requirements (e.g., infrastructure upgrading) are reviewed.
5. The facility master plan provides a detailed phasing/implementation plan, which also serves as a 'road map' to guide facility investments over a multi-year period.
6. It identifies immediate, short-term, and long-range "projects" with corresponding capital requirements and its sequencing. This is compared with current industry practice.

5.5.2 Impact Planning

Notes

Any facility will create an impact on the environment. This is also called an ecological footprint. Theoretically, the size of the ecological footprint should be minimized. Impact planning is the integration of commercial and practical environmental objectives to produce the optimum benefit for business and the environment.

The following features need to be protected and the impact on these also needs to be considered:

1. Vegetation/Tree cover
2. Wetlands, Swamps, Mangroves
3. Protected Areas
4. Lakes
5. Rivers and creeks
6. Sea coast

The impacts on these specific elements should be within the parameters of the environmental laws that protect environs of the site.

In addition, the topography, soil mixture and drainage must be suited to the type of building required. The soil must be capable of providing it with a proper foundation. It should not be a low-lying area. Ingress of excess water during monsoons should not disturb operations. Land improvements or piling and concrete rafting to provide protection and the required strength to the foundations always prove expensive. Even when the price of land is low, it may not prove to be economical to build on such sites.

In India we have laws to protect the air, water, and ground. Both air and water are impacted by the wastes that are produced and the manner in which wastes are disposed of. Will the plant be situated in a smoke-free zone? Can water and oil be discharged directly or must it be transported from the plant? What local agencies are available to provide solutions?

Recently there were news reports that oil seepage from an oil storage depot of Indian Oil Corporation in Bihar, had found its way into the water table. Water supply in the area has become unfit for human consumption. This raises questions of various threats to the environment from factory operations.

The legal requirements of the Government of India and the types of impacts that need to be controlled to meet environmental and local laws include the following:

1. Air pollution
2. Water pollution
3. Waste treatment
4. Solid waste disposal
5. Hazardous chemicals
6. Disposal of sludge
7. Noise
8. Dust
9. Radiation
10. Toxic chemicals
11. Industrial accidents
12. Chemical or fuel spills
13. Soil contamination
14. Water supply
15. Disease vectors
16. Smog
17. Acid precipitation
18. Ozone depletion
19. Global warming
20. Loss of biodiversity
21. Animal deaths
22. Visual impact
23. Landscaping

Notes

Notes **Infrastructure for Environmental Requirements**

Questionnaire

This identifies a number of services and features that may be linked to infrastructural requirements of the unit. *Who provides or is responsible for the following services, tools or actions?*

1 o - **Industrial Estate Authority**

2 o - **Operational Units**

3 o - **Government Authority**

4 o - **Private Sector**

5 o - **Others**

	1	**2**	**3**	**4**	**5**
Energy					
Centralized energy supply	o	o	o	o	o
Individual energy supply	o	o	o	o	o
Supply and recovery of waste heat (cogeneration)	o	o	o	o	o
District heating system	o	o	o	o	o
Energy from waste facility	o	o	o	o	o
Energy from renewable resources facility	o	o	o	o	o
Water					
Municipal service	o	o	o	o	o
Tube wells	o	o	o	o	o
Treatment facilities	o	o	o	o	o
Waste water disposal	o	o	o	o	o
Liquid waste disposal	o	o	o	o	o
Waste water recycling	o	o	o	o	o
Rain water harvesting	o	o	o	o	o
Sewage disposal	o	o	o	o	o
Solid waste					
Solid waste disposal	o	o	o	o	o
Composting of biological waste	o	o	o	o	o
Industrial liquid waste disposal	o	o	o	o	o
Hazardous waste disposal	o	o	o	o	o
Waste exchange clearing house	o	o	o	o	o
Multi-material resource recovery	o	o	o	o	o
Transport					
Traffic and transport management plan	o	o	o	o	o
Management					
Environmental monitoring	o	o	o	o	o
Effluent monitoring	o	o	o	o	o
Air emission monitoring	o	o	o	o	o
Environmental auditing	o	o	o	o	o
Environmental impact assessment	o	o	o	o	o
Environmental risk assessment	o	o	o	o	o

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Environmental technology assessment	o	o	o	o	o
ISO 14001 certification	o	o	o	o	o
Environmental training and education	o	o	o	o	o
Emergency preparedness and response capability	o	o	o	o	o
Self-regulation and operational standards	o	o	o	o	o
Insurance services	o	o	o	o	o
Miscellaneous					
Restoring natural features of the site	o	o	o	o	o
Landscaping and gardening	o	o	o	o	o
Analytical and laboratory services	o	o	o	o	o
Protection and security system	o	o	o	o	o
Safety, Fire and other hazards	o	o	o	o	o

Example: Considering the example of the Sahara Mall, KT Ravindran, an urban-planning expert at Delhi's School of Planning and Architecture, says that the daily exodus of shoppers from Delhi to Gurgaon's malls is already creating excruciating delays on the roads. But that's only the start of the trouble; because the electricity supply is unreliable in Gurgaon, malls will have to run their own diesel-powered generators, which cause significant pollution. And because the water supply is also limited, many of the malls have to dig wells and suck up groundwater, thus lowering the water level in the region.

In the Sahara Mall, the main source of power is the grid of HSEB. As Gurgaon is a power-cut prone area, an Auto Voltage Regulator (AVR) has been installed to ensure automatic regulation of voltage and 100 per cent standby power generated through four in-house continuous rating generators. The DG sets are installed in specially designed rooms to control noise.

Water requirements are supplemented by the use of two bore wells. The raw water is stored in soft water tank after curing through softening plant. Water is filtered and chlorinated and stored in domestic tank for drinking purpose. Limited roof-top rainwater harvesting is used to recharge the ground water.

Solid waste disposal is another issue. A garbage room is maintained in the upper basement of the Mall where all occupants place their garbage in closed PVC bags. Garbage is cleared from common areas dust and ashbins and stored in the garbage room. Garbage room is cleared at night on a daily basis. Low temperature has to be maintained in the garbage room for reducing decomposition and thereby foul smell.

5.5.3 Site Evaluation

Site evaluation should be the step after the facility impact assessment bears out the suitability of the site. The next steps are to look at the size of the land, the provision of infrastructure and utilities, the transportation facilities, land cost and site location, etc. Some of these considerations are discussed here under:

1. ***Size of site:*** The plot of land must be large enough to hold the proposed plant along with its utilities, waste and water treatment facilities, parking and access facilities and support services. The size of the plot must also be large enough to provide sufficient space for further expansion.

Notes

2. ***Utilities:*** The continuity of operations and the ability for uninterrupted production depends on the adequacy of utilities. The ability to overcome recurring problems associated with the supply of utilities needs to be evaluated and accountability assigned:

   (a) Possible restrictions on power availability.

   (b) Cost differentials at peak periods.

   (c) Availability of water supply during a 'hot' summer.

   (d) Quality of water-hard or soft, etc.

   (e) Connection cost of services from main supply lines to the intended plant.

   Costs associated with the volume and reliability of power, water and fuel supplies must be evaluated carefully. These costs are considerable and have to be borne over the life of the assets.

3. ***Transportation facilities:*** Rail and road networks should be close to the proposed plant to minimize the cost of creating private sidings to the rail lines and access roads. Some indication can be gained by looking at the present road and rail network serving the local community. The plant should also be easily accessible by car and public transport.

   Intangible factors to consider include the reliability and network of the available carriers, the frequency of service, and freight and terminal facilities, and distance from the nearest airport. These can reflect on the cost and time required to transport the finished product to market and raw materials to the plant. They may also impact on the time required to contact or service a customer. These are important issues that must also be considered.

4. ***Land costs:*** These are non-recurring costs and of little importance in the determination of the facility location. In general, the plant site will be one of the following locations: city location; industrial areas or estates; or interior areas.

   Locating an establishment can be in a (a) city, (b) industrial estate or industrial area, or (c) at a greenfield location. Each option has advantages and disadvantages. The criteria for choosing each of these locations are given below:

   (a) *City Location:*

      (i) Availability of high proportion of highly skilled employees.

      (ii) Fast transportation or quick contact with customers and suppliers.

      (iii) Size of plant often a limitation, small plant sites or multi-floor operations.

      (iv) Transportation of large variety of materials and supplies possible, but usually in relatively small quantities.

      (v) Urban facilities and utilities available at reasonable rates.

      (vi) Possible to start production with a minimum investment in land, buildings, etc., as these can usually be rented.

   (b) *Industrial Estates/Industrial Areas:*

      (i) Limitations in locating close to employee's homes.

      (ii) Often provided exemptions from high taxes.

      (iii) Freedom from strict city building and zoning restrictions.

      (iv) Infrastructure often not a major concern.

Notes

(v) Environmental concerns can be met at minimum cost outlay.

(vi) The site should be close to transportation and population.

(c) *Interior Greenfield Location:*

(i) Large land requirement.

(ii) Suitable to production processes/product which are dangerous or objectionable.

(iii) Requirement for large volumes of relatively pure water.

(iv) Often provided exemptions from high taxes.

(v) Limited availability of highly skilled employees.

(vi) Need to invest in infrastructure and housing.

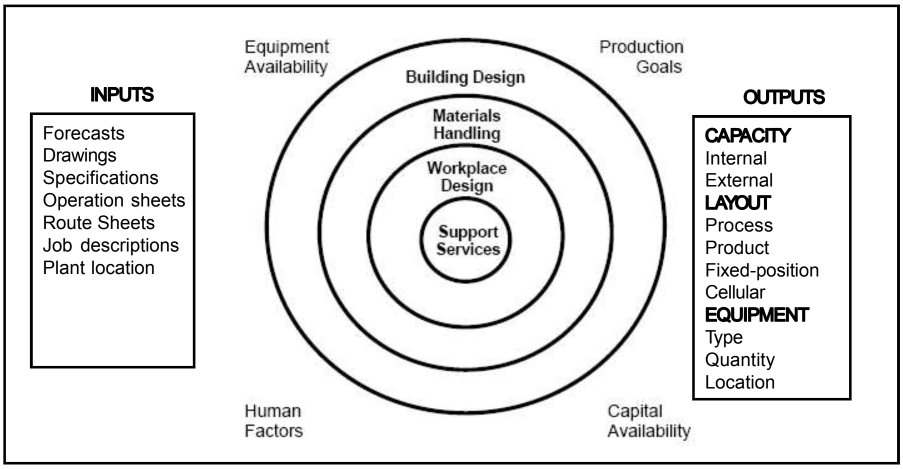
Plant location analysis is a periodic task. Management should recognize that successful businesses are dynamic. A location may not remain optimal forever.

Community Considerations

The proposed plant must fit in with and be acceptable to the local community. Full Consideration must be given to the safe location of the plant so that it does not impose a significant additional risk to the community. Adverse climatic conditions at site will increase costs. Extremes of low temperatures will require the provision of additional insulation and special heating for equipment and piping. Similarly, excessive humidity and hot temperatures pose serious problems and must be considered for selecting a site for the plant. Stronger structures will be needed at locations subject to high wind loads or earthquakes. Capital grants, tax concessions, and other inducements are often given by governments to direct new investment to preferred locations; such as areas of high unemployment. The availability of such grants can be the overriding consideration in site selection. State and local tax rates on property income, unemployment insurance, and similar items vary from one location to another. Similarly, local regulations on zoning, building codes, nuisance aspects and others facilities can have a major influence on the final choice of the plant site

5.5.4 Micro-level Planning

Figure 5.1: Facility Planning Model



Notes

Good micro level planning can affect an organization and determine how well it meets its competitive priorities by:

1. Facilitating the easy flow of materials and information,
2. Increasing the efficiency in the utilization of labour and equipment,
3. Increasing convenience of customers and thereby sales at a retail store,
4. Improving working conditions and decreasing hazards to workers,
5. Improving employee morale, and
6. Improving communication.

Facility planning at the micro level involves decisions about the functional layout and physical arrangement of economic activity centers. Economic activity centers are work related places that consume space: it could be a teller window in a bank or the space for customers to wait for their turns; it could be a machine, a work-bench or work-station; it could be a stairway or an aisle; it could be a cafeteria or storage space. These have many practical and strategic implications.

The goal of functional layout is to allow workers and equipment to operate as effectively as possible. In order to do so, the following questions need to be addressed:

1. What should the layout include for each economic activity center? The economic activity center should reflect decisions that maximize productivity. For example, a central tool room is often efficient for most processes, but keeping tools at individual work-stations makes more sense for many processes.
2. How much space and capacity does each economic activity center need? Space is a cost but inadequate space can reduce productivity and even create safety and health hazards.
3. How should each economic activity center's space be configured? The space, its shape, and the elements need to be interrelated.

Example: In a store the placement of the show windows, spaces planned so that products are visible and providing a pleasing atmosphere are necessary parts of the layout configuration decisions.

The location of an economic activity center has two dimensions that affect a center's performance:

(a) Relative location, or the placement of a center relative to other centers, and

(b) Absolute location or the particular space that the center occupies within the facility, both.

Where should each economic activity center be located? Location can significantly affect productivity. Employees who must frequently interact with one another should be placed close together so that interaction becomes easier; sections or departments should be planned to reduce time lost in moving material or traveling of personnel back and forth.

Task Interview any one businessman in your locality who owns either a production outlet or a large service outlet. Ask what all factors he kept in mind while choosing his site of operation.

Notes

5.6 Techniques of Locational Analysis

5.6.1 Factor Rating Method

Assume that an auto ancillary is planning to set up a factory to supply parts to Maruti. There are three location options identified by the company. The first is at Jammu, where the promoters are based; the second location is at Chandigarh where the company already has land; and the third is in Gurgaon, close to the principal's factory. How does the company choose the location using a Factor Rating Analysis?

Table 5.3 shows the factor ratings and the location scores that were considered in this particular case.

Table 5.3: Factor Rating Analysis

Factor	Factor Rating	Location Scores		
		Jammu	Chandigarh	Gurgaon
Required Amenities	4	3	7	9
Government Regulations	2	10	7	5
Ability to Expand Capacity	3	10	10	6
Easy Availability of Required Land	1	7	10	4
Availability of Skilled Labour	4	2	6	9
Impact Analysis	4	10	8	6
Ease of Funding	5	5	5	10
Proximity to Market	3	2	5	10
Proximity to Suppliers	5	2	6	9

In this type of analysis, the company chooses the factors that it considers most important in making the correct decision. The identified factors are rated on a scale of 1 to 5. A rating of 5 is given to the most important factor and 1 to the least important one. The factors that have been identified are given scores raging from 1 to 10 dependent on the advantages the site offers. Ten (10) is the highest score. This is called the location score.

Jammu gets very high scores in government regulations, ability to expand, and impact analysis. Government offers incentives relating to exemption of sales tax and lower income taxes in Jammu. As the promoters are based in Jammu, their ability to acquire assets to expand is going to be easier in Jammu. As the level of industrialization in Jammu is low, the level of the investment in clean technologies is expected to be low as the base levels of pollution are low.

Chandigarh gets very high scores both on ability to expand and availability of required land. This is because the company already owns sufficient land at Chandigarh.

Gurgaon gets very high scores at ease of funding, because Maruti has a policy of investing in its ancillaries around Gurgaon as a joint venture partner. This would not only ease the fund requirements of the owners, but would also make availability of additional funds easier. It would be located adjacent to its market, Maruti Udyog Ltd., and most of the suppliers of inputs would be relatively close.

Notes

Table 5.4: Composite Location Scores

Factor	Factor Rating	Composite Location Scores		
		Jammu	Chandigarh	Gurgaon
Required Amenities	4	12	28	36
Government Regulations	2	20	14	10
Ability to Expand Capacity	3	30	30	18
Easy Availability of Required Land	1	7	10	4
Availability of Skilled Labour	4	8	24	36
Impact Analysis	4	40	32	24
Ease of Funding	5	25	25	50
Proximity to Market	3	6	15	30
Proximity to Suppliers	5	10	30	45
		158	208	253

We can now convert the factor rating and location score into a composite score. This is done easily by multiplying the factor rating with the location scores. The product is the composite score for the location. The totals of all the factors are added and compared. The location with the highest composite location score is the preferred location. This has been worked out in Table 5.4.

Based on the Factor Rating Analysis, Gurgaon is the best site for locating the new plant. It is a significantly better location than Chandigarh or Jammu based on the factors that were identified and the salience that was given to these factors.

There is an implicit assumption in this model that either the cost differences between the locations are not significant or that the benefits also reflect the cost advantages of the location decision. This assumption may or may not be true. In the example we have discussed above, the cost of land in Gurgaon could be extremely high, while the historical cost of the Chandigarh land may be insignificant. The cost of pollution control devices required at Gurgaon may be significantly higher than that required in Jammu.

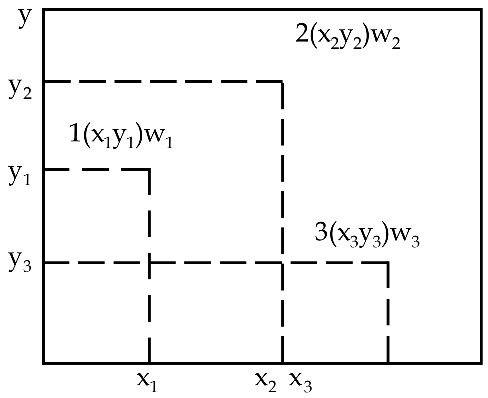
It is often better to use this model along with a quantitative model and compare the results before taking a facility location decision. A number of other models are available and commonly used that quantify both the benefits and costs of a specific location compared to others.

5.6.2 Centre of Gravity Method

In general, transportation costs are a function of distance, weight and time. The center-of-gravity, or weight center, technique is a quantitative method for locating a facility such as a warehouse at the center of movement in a geographic area based on weight and distance. This method identifies a set of coordinates designating a central location on a map that minimises the weighted average of the weight transported to all other locations. As such, it implicitly assumes that by minimising the weight shipped, costs are also minimised.

Notes

Figure 5.2: Grid-Map Co-ordinates for Centre-of-Gravity Method



The starting point for this method is a grid map set up on a Cartesian plane, as shown in Figure 5.2. Note that there are locations identified as 1, 2 and 3, each at a set of coordinates (x_1, y_1) identifying its location in the grid. The value w_1 is the annual weight shipped from that location. The objective is to determine a central location for a new facility that minimises the distance these weights are shipped.

The coordinates for the location of the new facility are computed using the following formulas:

$$x = \frac{\sum_{i=1}^{n} x_i w_i}{\sum_{i=1}^{n} x_i w_i} \quad b = \frac{\sum_{i=1}^{n} y_i w_i}{\sum_{i=1}^{n} w_i}$$

Where

x, y = Coordinates of the new facility at center of gravity

x_1, y_1 = Coordinates of existing facility i

w = Annual weight shipped from facility i

5.6.3 Least Cost Method

Least cost method suggest that the agriculture and industries should locate their activities as close to the market as possible, in order to get benefit of least cost of transportation of goods they produce.

According to this method, a site is chosen for industrial development where total costs are theoretically at their lowest, as opposed to location at the point of maximum revenue.

A model of industrial location proposed by A. Weber, assumes that industrialists choose a least-cost location for the development of new industry. The theory is based on a number of assumptions, among them that markets are fixed at certain specific points, that transport costs are proportional to the weight of the goods and the distance covered by a raw material or a finished product, that perfect competition exists, and that decisions are made by economic man.

Weber argued that raw materials and markets would exert a 'pull' on the location of an industry through transport costs. Industries with a high material index would be pulled towards the raw material. Industries with a low material index would be pulled towards the market.

Once a least-cost location has been established, Weber goes on to consider the deflecting effect of labour costs.

Notes

Case Study

Sahara Mall

Sahara India Pariwar is a highly diversified group that started as a small-scale enterprise in 1978 at Gorakhpur, Uttar Pradesh. The group has diversified into various ventures such as infrastructure and housing, aviation, media and entertainment, communication, hotels, hospitals, life insurance, mutual funds, housing finance, consumer products and retail chain, tourism, computer manufacturing, etc., apart from maintaining its position as India's largest para banking (deposit mobilization) company in India. Today, after 27 years of operation, Sahara India Pariwar has emerged as one of the fastest growing Indian business conglomerates with an asset base of over US $ 10.87 billion (INR 50,000 crores), 1707 establishments and over 0.91 million workers.

The increasing size of the urban population and the larger disposable incomes of the middle classes made infrastructure and housing an attractive option for the Sahara Pariwar. The group has planned over 200 townships spread over the country. With India's economic boom and revolution in the retail market, it was not surprising that the Sahara Group decided to start by building the Sahara Mall, located in Gurgaon. The Sahara Mall with a glass and metal facade is a Super Mall spread over 2,37,000 sq. feet. This Mall has been designed by W.S. Atkins, and constructed by Larsen & Toubro's ECC division.

The objective of the Group was to make this into a unique shopping mall comprising company owned brand outlets and flagship stores which would promise a complete range of products and latest offerings. The shopping mall was to set new standards in contemporary design and latest facilities and amenities making it a most preferred shopping zone for the consumers with international class retailing environment.

The Sahara Mall is situated on the six lane main Mehrauli-Gurgaon Road, just 15 minutes drive from Indira Gandhi Airport and a stone's throw away from Bristol Hotel. The Mall is centrally air-conditioned. As Gurgaon is a power cut prone area, Sahara Mall relies on 100 per cent standby power generated through four in-house continuous rating Generators The DG sets are installed in a separate, specially designed room to control noise. It offers excellent parking facility for about 1000 vehicles. The Mall has a state-of-the-art CCTV system to monitor safety and security of the shoppers and vehicles parked in the premises. Five elevators are provided at the Mall. One is exclusively used by the anchor store Big Bazaar. One is used as a service lift and three lifts are used by customers/others. Escalators provide ascending or descending facility for people as a continuous process.

In the case of developed countries, entertainment, food and apparel are anchors for any mall. However, according to research, in India the pattern is not the same. A large part of the visitors to malls come to see a movie. As people spend larger periods of time in the malls, they look not only for a real shopping experience but for a wholesome eating experience as well. Over 60 per cent of people who visit malls watch a movie and end up eating out, but only 20-30 per cent actually shop.

Other attractions that customers look for to find a mall attractive include:

1. ***A Good Anchor:*** Almost always the Mall has to have an anchor store. At Sahara Mall the biggest crowd puller is the Big Bazaar, a discount store. The anchor store also communicates the positioning of the mall. So people who believe in "value for money" would consider Sahara as the right choice.

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2. ***A Kids' Center:*** Young mothers would like not to divide their attention between the various stores on one hand and her kid on the other. Young couples prefer malls with kid centers where caretakers are present. They are ready to pay for it.

3. ***Disciplined Parking:*** Most people who visit shopping malls do so in their own vehicle. Visitors expect to get parking space and guidance inside the parking, and speedy acceptance of payment and verification.

Though Sahara has a large discount store, with Big Bazaar as its major traffic puller, it doesn't have a multiplex so far. Mr. Asad Ahmed, the Assistant General Manager and Chief of Planning of the Sahara Pariwar, was mulling over the idea whether they should add a multiplex to the Sahara Mall in order to improve its attractiveness. A multiplex would require a built-up area of 37,000 sq. ft. He was aware that the people who visit malls to watch a movie may end up eating out, but only 40-45 per cent actually shop. Would this constitute reason enough to invest in the multiplex?

Questions

1. Comment on the facility planning of the Sahara Mall.
2. Can you give suggestions for expansion of the mall?

5.7 Summary

- Facilities location may be defined as selection of suitable location or site or place where the factory or plant or facilities to be installed, where plant will start functioning.
- The development of a location strategy depends upon the type of firm being considered. Industrial location analysis decisions focus on minimising costs; retail and professional service organisations typically have a focus of maximising revenue.
- One of the major reasons for new facilities is the global economic boom that has been accompanied by an enhancement of capacity worldwide.
- Well-planned facilities enable an organization to function at its most efficient and effective level, offering real added value improvements to the organization's core business.
- Manufactured products differ from many service products as production may take place at a location, and then the goods are distributed to the customer. Often the source of raw materials is an important factor in deciding locations.
- Locating plants and facilities near the market for a particular product or service may be of primary importance for many products in the sense that location may impact the economics of the manufacturing process.
- For companies that produce or buy heavy and bulky low-value-per-ton commodities as are generally involved in import and export activities, shipping and location of ports may be a factor of prime importance in the plant location decision.
- In service, the capacity to deliver the service to the customer must first be determined; only then can the service be produced.
- When the site selection process is initiated, the pool of potential locations for a manufacturing facility is, literally, global. Since proximity to customers is not normally an important location factor for a manufacturing plant, countries around the world become potential sites.

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- At macro level, the plans of the site are developed. These plans should include number, size, and location of buildings. It should also include infrastructure such as roads, rail, water, and energy.
- Facility master planning strategy involves examining the existing facilities; the sizing of future facilities and site amenities; the integration of these facilities into the site; traffic flow and circulation; and the analysis of any impact that this development will have on the site with respect to environmental issues.
- Facility planning at the micro level involves decisions about the functional layout and physical arrangement of economic activity centers.
- There are a few techniques using which locational analysis is done: factor rating method, centre of gravity method and least cost method.

5.8 Keywords

Centre of Gravity: Location based on the proximity to warehouse or other major place of interest.

Ecological Footprints: Impact of the facility on the environment.

Facility Location: Selection of suitable location or site or place where plant or facilities to be installed.

Facility Master Plan: Helps plan the right services consistent with firm's mission.

Facility Planning: Providing physical capability to add value to the organisation.

Factor Rating Method: Very simple method to relate factors and their salience to facility location decisions.

Heavy Industries: Plants that are relatively large and require a lot of space.

Impact Planning: Integration of commercial and practical environmental objectives to produce optimum benefits for business and environment.

Least Cost Location: A site is chosen for industrial development where total costs are theoretically at their lowest.

Light Industries: Perceived as smaller, cleaner plants that produce electronic equipment and parts used in assemblies, or assembled products.

5.9 Self Assessment

State whether the following statements are true or false:

1. The choice of location is more on a personal basis rather than being based on any specific factors.
2. The location strategy, if it exists, is a constant function of only the cost of location.
3. The type of industry of the organization will also impact the choice of location of plant.
4. The customer base and income level of people around the site is never considered while making a choice for plant location.
5. Labor pool and transportation system are country specific factors in deciding the plant location.

6. Environmental regulation and raw material availability are important considerations while selecting a part of the country as plant location.
7. State amenities and inducements also tend to affect the choice of plant location among various states.
8. A low cost overseas plant location will not be chosen if there is no economic and political stability in the region.
9. Industry concentrations have developed in certain states on account of raw material availability and strong customer base.
10. The site evaluation process can never rely on secondary sources of data.

Fill in the blanks:

11. Labor climate includes cost of labor, availability of labor, ... and ....
12. It is important that the plant location be near the .... and ....
13. A software company may choose Bangalore or Gurgaon as its office location on account of .... concentration.
14. In the location factor rating system, each factor is assigned a weight from .... to .... and a score is assigned from .... to .... based on which plant location decision is made.
15. Consumer consideration in deciding the office location becomes .... important in case of service industry.

5.10 Review Questions

1. "The development of a location strategy depends upon the type of firm being considered". Discuss
2. "Well-planned facilities offer real added value improvements to the organization's core business." Explain the statement.
3. "Location is a critical element in determining fixed and variable costs for both industrial and service firms." Substantiate.
4. Suppose you are a businessman producing garments, looking to start your business operations in some other country. What factors will you keep in mind while setting up your business abroad?
5. "Manpower is the most costly input in most production systems." Analyse this statement.
6. What do you mean by the 'right services' in facility master plan?
7. "Any facility will create an impact on the environment." Elucidate.
8. Why is it important to evaluate a site beforehand? Discuss the least cost and centre of gravity method and their relevance.
9. If you expand your existing company by opening a new division in a foreign country, should the new division be staffed by local personnel or by personnel imported from the parent organisation? Explain.
10. The governing principle is that a location of plant should be fixed in such a manner that people interested in its success can sell goods most profitably and manufacture them at least expenses. Explain how this objective can be achieved?

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11. Give main criteria of plant location in following cases: Wide range of volumes or bulky resources, Medical research centre/hospitals, fire stations, public/professional services, cotton/textile industry, sugar industry, cement industry, jute industry, iron and steel industry/steel mill, paper industry, coal industry.
12. How does International Location decision differ from Domestic Location consideration? You may answer by briefly identifying areas that are unique to International locations.
13. Although facility location is a planning decision, it has implications for decisions in the organising and controlling and sub-function. Explain.
14. What are the special problems faced by service operators like Sahara Pariwar, in locating new facilities?
15. The Indian Seamless Tube Company Ltd. which has distribution plants in Gujarat and Andhra is considering adding a third assembly and distribution plant either in Ahmedabad, Bangalore or Cochin. The company has collected the following economic and other relevant data:

Factor	Cochin	Ahmedabad	Bangalore
Transportation cost/week	₹ 780	₹ 640	₹ 560
Labour cost/week	₹ 1200	₹ 1020	₹ 1180
Selected criteria scores (Based on a scale of 0-100 points) Finishing material supplied	35	85	70
Maintenance facilities	60	25	30
Community attitude	50	85	70

Company Management has pre-established weights for various factors ranging from 0-10. They include a standard of 1.00 for each ₹ 10 per week of economic advantage. Other weights that are applicable are 1.5 on finishing material supply, 0.8 on maintenance facilities and 2.0 on community attitude. Maintenance also has a minimum acceptable score of 30. Develop a quantitative factor comparison for the three locations.

16. From the following data select the most advantageous location for setting a plant for manufacturing television sets:

		Bhopal	Mandideep	Vidisha
i.	Total initial capital expenditure	400,000	400,000	400,000
ii.	Total expected sales/year	500,000	600,000	500,000
iii.	Distribution expenses	80,000	80,000	150,000
iv.	Raw material expenses	140,000	160,000	180,000
v.	Power and water supply expenses	80,000	60,000	40,000
vi.	Wages and salaries	40,000	50,000	40,000
vii.	Other expenses	50,000	80,000	60,000
viii.	Community attitude	indifferent	wants	indifferent
ix.	Employee housing facilities	poor	excellent	good

17. A manufacturer of farm equipment is considering three location (A, B and C) for a new plant. Cost per year at the sites are ₹ 2,40,000, ₹ 2,70,000 and ₹ 2,52,000 respectively. Whereas variable costs are ₹ 100 per unit, ₹ 90 per unit and ₹ 95 per unit respectively. If the plant is designed to have an effective system capacity of 2500 units per year and is expected to

operate at 80 per cent efficiency what is the most economic location on the basis of actual output.

18. Mr. satish is a manufacturer of IT farm . He is considering three location (A, B and C) for a new plant. Cost per year at the sites are ₹ 9,40,000, ₹ 3,80,000 and ₹ 5,72,000 respectively. Whereas variable costs are ₹ 100 per unit, ₹ 90 per unit and ₹ 95 per unit respectively. If the plant is designed to have an effective system capacity of 2500 units per year and is expected to operate at 90 per cent efficiency what is the most economic location on the basis of actual output.

19. The Indian Seamless glass Company Ltd. which has distribution plants in Up and HP is considering adding a third assembly and distribution plant either in Delhi, Gurgoan or noida. The company has collected the following economic and other relevant data:

Factor	Delhi	Gurgoan	noida
Transportation cost / week	₹ 790	₹ 890	₹ 934
Selected criteria scores(based on scale 0-100 points)	45	34	65
Labour cost	₹ 1900	₹ 2300	₹ 1800
Community attitudes	67	80	70
Maintenance facilities	60	68	35

Company Management has pre-established weights for various factors ranging from 0-10. They include a standard of 1.00 for each ₹ 10 per week of economic advantage. Other weights that are applicable are 1.5 on finishing material supply, 0.8 on maintenance facilities and 2.0 on community attitude. Maintenance also has a minimum acceptable score of 30. Develop a quantitative factor comparison for the three locations.

20. Mr. neerat Mathur is a manufacturer of farm equipment . He is considering three location (A, B and C) for a new plant. Cost per year at the sites are ₹ 3,40,000, ₹ 2,80,000 and ₹ 2,72,000 respectively. Whereas variable costs are ₹ 100 per unit, ₹ 90 per unit and ₹ 95 per unit respectively. If the plant is designed to have an effective system capacity of 2500 units per year and is expected to operate at 80 per cent efficiency what is the most economic location on the basis of actual output.

Answers: Self Assessment

1. False
2. False
3. True
4. False
5. True
6. True
7. True
8. True
9. True
10. False
11. Work ethics of labor; labor problems
12. Customers; suppliers
13. Industry
14. 0, 1; 0, 100
15. More

Notes

5.11 Further Readings

Books

Canary, Patrick H., *International Transportation Factors in Site Selection,* (October 1988): 1217-1219.

Chan, Yupo, *Location theory and Decision Analysis with Facility – Location and Land-use Models,* Cincinnati, OH: South-Western College Publishing, 2001.

Hurter, Arthur, P., Jr., and Joseph S. Martinich, *Facility Location and the Theory of Production,* Boston: Kluwer Academic Publishers, 1989.

Schniederjans, Marc J., *International Facility Acquisition and Location Analysis,* Westport, CT: Quorum, 1999.

Upendra Kachru, *Production and Operations Management,* Excel Books, New Delhi

Online links

classes.uleth.ca/200102/mgt2070y/Notes/Handout6.doc

www.courseworkbank.co.uk/.../factors_affecting_location_a_business_1246/

www.economyprofessor.com/.../least-cost-location-theory.php

www.modeladvisor.com/specific_use/operation.../om-center.pdf

www.springer.com/business/production/.../978-3-7908-2150-5

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Unit 6: Quality Assurance and Control

CONTENTS

Objectives

After studying this unit, you will be able to:

- Discuss quality control and process capability
- Explain statistical techniques for quality control
- Describe modern concepts like TQM, quality circles, JIT etc.
- Explain the shift of emphasis from quality control to quality assurance
- Describe KAIZEN

Introduction

Quality, as it is said, is not by chance but by intention. All successful companies value quality as a system in their manufacturing systems. It is on account of high quality that German cars, Swiss watches, Japanese electronics etc. have established global acceptance. Thus, it is imperative for all organizations to make systems for quality management and control. Let us now study the techniques and standards for quality control accepted globally.

6.1 Quality Control Defined

Quality Control implies working to a set standard of quality which is achievable and which has a ready market. Thus Quality Control means adherence to a standard or prevention of a change from the set standard. In general, this is essential because when there is acceptable quality, a manager must ensure that there is no deterioration from the standard. However, in a changing world one is often faced with the fact that the quality which is acceptable today by the customer may not be acceptable to him a year later. Therefore, there is need for a breakthrough, (creation of change) for improving existing standards. Thus preventing change (control) and creating change (breakthrough) are two important functions of quality management. Unfortunately a large number of managers simply have no time for breakthrough because they are obsessed with day-to-day problems of keeping controls at the existing levels.

Many breakthrough programmes call for a change of the existing practices. There is always a resistance to change specifically if the objective is not properly understood. This is because the people likely to be affected by the change are not involved in breakthrough efforts. Many breakthrough programmes have failed to click because of this attitude. The training programme to suit the requirement of the organisation and person involves has been found to be helpful in ensuring breakthrough in attitude.

Quality control has the objective of coordinating the quality maintenance and improvement efforts of all groups in the organisation with a view to providing full consumer satisfaction. Statistical quality control enables these objectives to be attained most economically reducing scrap and rework, reducing machine downtime and minimising inspection. A successful statistical quality control programme should result in "better quality to the consumer at a lower cost". One would instinctively recognise two aspects of quality, quality of design and quality of performance. The difference between an ambassador and a maruti is the quality of design. Once the quality of design has been established, quality of performance concerns itself with how well the target is hit. SQC is, in general, concerned with the quality of performance but it is also a fact that SQC applications have occasionally resulted in the improvement of the design as well.

Caselet

Quality Control brings Cheers to Coonoor Farmers

Quality upgradation efforts led by the Tea Board and the United Planters' Association of South India (UPASI) have helped increase the sales and prices of tea from Coonoor. While there has been substantial decline in sales and prices of South Indian tea in general, sales at Conoor auction centre increased to 74.555 million kg during the calender year 2001 from 70.967 million kg in the previous year. Average price also was better at ₹ 41.46 a kg in 2001 than ₹ 39.01 in 2000.

The South Indian tea industry is passing through a severe crisis of low prices mainly due to poor quality and the dependence on a single export market, Russia. With the global

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over supply of tea and the demand of the Russians for better quality, South Indian tea is losing Russian market also. Even in the domestic internal market, the Tea Board found in a survey that the South Indian tea "was becoming unpopular because of its poor quality".

According to former Coonoor Tea Trade Association (CTTA) chairman Dipank Shah, who relinquished office last month, the tea from Coonoor "can get consumer acceptance and realise higher prices only if the industry is committed to quality".

In his address to the 9th annual general meeting (AGM) of CCTTA recently he said that Tea Board and UPASI had taken a number of steps to bring about qualitative changes in the plucking and processing of tea. Tea Board took a delegation of growers and manufacturers to the North Indian tea market to make a comparative study of the quality of tea sold there and those produced by the Southern industry.

The result, in the words of Mr Shah, "Was heart-breaking as it was found that tea of only a couple of factories matched with what the buyers wanted."

Realising the urgent need for quality upgradation of the South Indian teas Tea Board and UPASI embarked on educating the growers and manufacturers.

The farmers were trained to maintain plucking standards and the bought leaf factories to improve quality of their produce.

Mr Shah said there was no immediate impact on prices "because of the demand/supply position". He denied the accusation that the prices were manipulated by trade cartels.

Gradually the improved quality was realised by the upcountry buyers and they came forward to offer higher prices. "Price of good tea improved by atleast ₹ 15 per kg and plainer ones by ₹ 4-6," he said.

Source: Article at financialexpress.com

6.2 Collection and Presentation of Data

Objective decisions in quality management can be built only on facts. The decisions naturally would be as good or as bad as the data on which they are based. Thus, it is important to build that base of sound lines.

Example: Standardisation of inspection procedures is essential if it is desired to compare two inspectors, shifts etc., or to have, even a meaningful dialogue with the customers.

Generally, an investigation will compromise of planning, collection, scrutiny and analysis of data, interpretation of result of analysis and finally report writing to enable appropriate decision making by the concerned executives. While planning collection of data, one should take into account the objectives of the study and the availability of past experience or data on the subject. The method of analysing data should also be borne in mind at this stage. Other points to be pondered over at the planning stage are:

1. In what form and on what characteristics to collect data variable or attribute?
2. How much data should be collected?

These questions are answered in the succeeding paragraph.

Data can be of two types: attribute and variables. The former is generated when items are inspected and classified as good or defective, number of off beats in a unit time, number of defective moulds, number of NTs rejections etc. The latter involves the actual measurement of

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the degree of conformance to requirements diameter, weight, temperature, chemical composition, hardness etc. The pros and cons of the two types of data are summarised in the Table 6.1:

Table 6.1: Comparison of Attribute and Variable Data

Characteristic	Attribute	Variable
Cost of measuring instrument	Nil or low	High
Grade of operator	Unskilled/Semiskilled	Skilled
Speed	Quick	Slow
Recording of data	Simple	Complex
Overall cost per observation	Low	High
Information value per observation	Low	High
Number of observations needed for valid inference	Large	Small

Variable data will naturally be preferred for control purpose where the characteristic concerned is important.

6.3 Major Statistical Measures for "Central Tendency"

When data are examined, it will normally be found that a few values will be extremely high or extremely low and most of the values tend to be concentrated within a region which is somewhere between the two extremes. This phenomenon is known as central tendency. The measure of central tendency is thus a parameter in a series of statistical data which reflects a central value of the same series.

The following are the measures most commonly used to describe the central location about which a number of observations are grouped:

1. ***Mean*** (the ordinary "average") is usually used for symmetrical or near symmetrical distributions, or for distributions which lack a clearly dominant single peak.
2. ***Mode*** (value which occurs most often in data) is usually for severely skewed distributions, describing an irregular situation where two peaks are found, or for eliminating the effects of extreme values.
3. ***Median*** (the middle value when the figures are arranged according to magnitude) is usually used for distributions where the mode is not well defined, for reducing the efforts of extreme values, or for data which can be ranked but are not economically measurable shades of colour, visual appearance, odours.

Mean is the most generally used measure of central tendency in quality work. It is employed so often to report average size, average yield, average per cent of defective etc. Control charts have been devised to analyse and keep track of it. Such control charts can give the earliest obtainable warning of significant changes in central values of the group.

The mode is the value which corresponds to the greatest frequency, the peak value. It is the number that appears most often or most commonly and is in this sense most typical of the data. Understandably, then, the mode is the measure instinctively picked out when bar charts are used. For example, to compare sizes of inspected parts with blue print limits. It is the size of the parts described by the tallest bar.

In contrast, the median is generally reserved for a few special situations such as destructive testing, where it can sometimes be used, through a statistical trick, to reduce the number of parts tested. If, for example, the average of five parts tested is used to decide whether a life test has been met, then the life span of the third part to fail can sometimes be used to predict the average of all five, and thereby the result of the test becomes much sooner.

Dispersion

The extent to which the data are scattered about the zone of central tendency is known as the dispersion. Measure of dispersion is the second of the two most fundamental measures in statistical analysis.

Followings are the measures of dispersion, Range, Variance and Standard Deviation, Mean Deviation, Coefficient of Variation.

1. ***Range:*** The simplest measure of dispersion in a sample is the range which is defined as the difference between the largest and the smallest values included in the distribution.

   Range = largest value minus smallest value = R. The advantage of the range as a measure of dispersion is its utmost simplicity. However, the range can sometimes be misleading because of the effect of just one extreme value.

   The range is the most commonly used measure of dispersion in every day life. Examples are:

   (a) In weather forecast min. and max. temp. in a day.

   (b) In SPC (Statistical Process Control) mean and range charts.

   (c) Used in studying variation in money rates, share prices.

2. ***Variance and Standard Deviation:*** A second measure of dispersion is the variance.

   This is defined as the measure of dispersion about the mean and is determined by squaring each deviation, adding these squares (all of which necessarily have plus signs) and dividing by the number of them.

   Expressed as a formula: $\Sigma \frac{d_i^2}{n}$

   where $d_i = (x_i - x)$ is the deviation from the mean.

   While the variance is of fundamental importance in statistical analysis, the most useful measure of dispersion is the square root of the variance, known as the "standard deviation".

   It is easily seen that when the data is in the form of a frequency distribution:

   Std. Deviation = σ = sq. of Variance

   $$= \text{sq. of } \Sigma \frac{d_i^2}{n}$$

   When the frequency of the variable is given (f)

   Std. Deviation = r = sq. root of Variance

   $$= \text{sq. root of } \Sigma \left(\frac{f_i d_i^2}{n} \right)$$

3. ***Mean Deviation:*** Mean Deviation in a set of observations is the arithmetic average of the deviations of each individual observation from a measure of the central tendency (mean, mode, median).

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Mean deviation from mean = $\Sigma \frac{d}{n}$ where 'd' is deviation from mean.

Mean deviation from mode = $\Sigma \frac{dk}{n}$ where 'dk' is deviation from mode.

Mean deviation from median = $\Sigma \frac{dm}{n}$ where 'dm' is deviation from median.

Significance of Mean Deviation: As the mean deviation is not affected very much by the extreme values as is the case with Standard deviation, the Mean deviation is useful for many studies in economic field, e.g., computing the personnel distribution of wealth in a community or a nation.

4. ***Coefficient of Variation:*** As standard deviation is analogous to some absolute error being based on the deviations of observations from the central value which may be looked upon as the true value, a measure of relative dispersion is comparable to a measure of relative error. Such a measure, to be of any use should be free from any units for the sake of comparability. The most commonly used measure of this type is the co-efficient of variation given by

$$c.v = 100 \times \sigma / X$$

where σ is the standard deviation and $\bar{X}$ is the mean. The pth percentile of a variable refers to the value below which p% of the observation lie. For example, the median is the 50th percentile.

The percentiles can be obtained by drawing a graph of the cumulative frequencies in 'y' axis against the end of the class interval upto which the frequencies are cumulated in x axis and reading off the 'X' value corresponding to any desired percentile value.

6.4 Chance and Assignable Causes of Variations

However, best the methods of transformation (for conversion from Inputs to Outputs) be, no two pieces of output produced even under the most modern machines would be identical. Variation is inevitable.

Variation consists of two parts:

1. ***Chance causes:*** This is the variation which is natural or inherent in the process.

2. ***Assignable causes:*** This variation is unnatural or external due to assignable causes that can be traced.

Variations resulting from the assignable causes which can be traced, show some pattern and follow the statistical laws, i.e., laws of distribution normal, poisson, hyper-exponential, etc.

Example: Number of machines under breakdown, variation in alloy steels sheets rolled/forged.

The pattern of distribution can be predicted from the samples of size 'n' taken out of the population (N). The process is said to be under statistical control if the process need not necessarily yield products confirming to specifications as the process under statistical control produces results which conform to the control limits. The main objective of quality control is to present defects during production.

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The differences between the chance causes of variation and assignable causes of variation are given below:

Table 6.2: Differences between the Chance Causes of Variation and Assignable Causes of Variation

Chance Causes of Variation	Assignable Causes of Variation
1. It consists of many individual causes.	1. It consists of one or a very few individual causes.
2. All causes taken together normally amount for a substantial amount of variation.	2. Any one assignable cause can lead to a large amount of variation.
3. In case of raw materials these can be within the conformance specifications.	3. In case of raw materials, the entire lot or batch may be defective.
4. In case of running of a machine, there can be slight variation of the machine.	4. In case of a machine, the faulty machine set up gives rise to assignable cause variations.
5. Lack of human perfection in chance variations in setting or reading instruments.	5. Setting or reading of precise instruments by an untrained operator gives rise to assignable cause variation.
6. The chance variation cannot be economically eliminated from the process.	6. Assignable cause variation once detected can be eliminated and the action of centrally assignable cause is usually economically justified

Inspection in a manufacturing industry is carried out to compare products with known standards or specifications. To ensure the specified quality for the acceptability of the product, inspection stages are:

1. ***Incoming Raw Materials Stage:*** Here, the inspection is carried out to find whether the incoming lot is rejectable/acceptable for the manufacturer under the agreed terms of inspection plan. Single sampling plans and multi-sampling plans are in use for this purpose.

2. ***Process Control:*** Inspection during manufacturing is termed as Process Control Inspection. The inspection is carried out to find the quality of products being produced is good or bad and take action to bring the process under control. Process inspection should be done at appropriate points in the process so as to provide an immediate and accurate reflection of the quality status and condition of all parts being processed.

   Process Inspection may include the following checks:

   (a) *Set up and first piece inspection:* First piece inspection is established by checking the first item produced in the production set up. It will establish whether the machine set up, jigs & fixtures, and gauges are correct or not, and whether proper material is being used for the job. It also eliminates the necessity of scrapping a substantial part of production, run by locating the cause for rejection and correcting the deficiencies before production starts. Therefore, the production should not begin until the first piece found is acceptable.

   (b) *Patrol inspection:* Patrol inspection is perhaps the most crucial of all functions to keep the process in control throughout the production. It consists of inspection at appropriate intervals of time to verify conformity during manufacturing and is also known as floor inspection. This inspection may be conducted by operators/inspectors monitoring specified operations or by automatic inspection.

   Whatever applicable, the last piece must be included in the patrol inspection.

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3. ***Final Inspection:*** Final inspection of finished goods before these are despatched to next stage of production or customer helps in locating various assignable causes and taking suitable remedial actions.

   (a) Errors associated with inspection

   The errors erupt in due to the followings:

   (i) Lack of understanding among standards of inspection.

   (ii) Lack of consistency among various inspectors.

   (iii) Improper sampling from the source population.

   The errors at (i) & (ii) can be minimised but not eliminated altogether whereas the error at (iii) can be eliminated through the choice of a correct sampling plan.

   (b) Differences between 100% inspection and Sampling inspection

Table 6.3: Differences between 100% Inspection and Sampling Inspection

Hundred per cent Inspection	Sampling Inspection
1. Total cost of inspection is very high and at times it is prohibitive.	1. As volume of inspection is very low and hence total cost of inspection involved is low.
2. This inspection is subject to errors due to operator's fatigue, negligence and due to poor supervision by inspectors and results cannot be predicted with accuracy.	2. The sampling inspection is based on scientific sampling plan system and hence is free from such errors and results can be produced accurately.
3. No Sampling error.	3. As the method is based on sample drawn from the population, hence it is to sampling error. However, subjected the magnitude of sampling error can be estimated.
4. This method of inspection is not at all suitable for destructive testing.	4. Sampling inspection is the only way of inspecting for a destructive test.

Thus, we may infer that sampling inspection is generally superior to hundred per cent inspection.

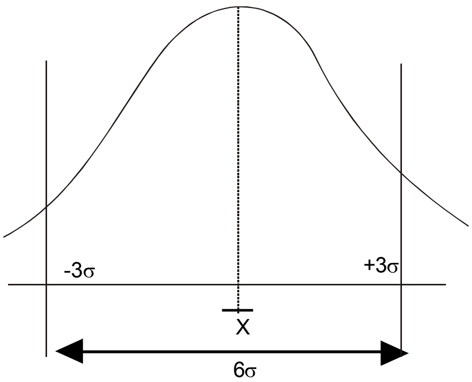
Task What is your perception of quality? How do you measure quality of your work?

6.5 Process Capability Defined

The Process Capability may be defined as the capability of a process. This can be evaluated from the data which is free from assignable causes and hence the extent of variation exhibited by it is only under the influence of the chance causes alone. In case it is not possible to remove the assignable causes of, at least, we should get these (assignable) causes segregated through 'Tests of Significance' the difference between the reference value and the measured value of samples. The number of units in each sample is called 'Sample Size'.

Notes

Figure 6.1: Process Capability



Procedure for Evaluation

This involves the following steps:

1. Collect data on a number of rational groups and review them for consistency or homogeneity.
2. Eliminated data which does not conform to the general pattern observed. If the data gets eliminated by more than 1/3rd, then reject the entire data and collect fresh data till homogeneity is achieved.
3. Calculate the process capability as given below: Calculation of Process Capability Attribute data
   (a) Uniform Sample Size, n = number of observations in each sample.
      (i) Count the number of samples say k = 25,
      (ii) Let sample size (number of observations in each sample) = n,
      (iii) Add all the defectives observed in all the 25 samples, summation of defects =d,
      (iv) Find m = np = D/k where 'p' is the proportion defective,
      (v) For p < 0.10, read limits from the concerned statistical table, against the value of 'm',

      Else (m >= 0.10),

      Calculate limits as $np \pm 3\sqrt{n.p.q}$, where q = (1 – p),
      (vi) *Test for homogeneity:* See whether all readings are within Control Limits, if so, accept the data as homogeneous. Otherwise, reject the readings (observations) which are outside control limits and again test for homogeneity. If the total number of observations rejected are more than one-third reject the entire data and fresh data should be collected.
   (b) Variable sample size (number of observations in each sample not uniform)
      (i) Let number of samples = k
      (ii) Let $n_1, n_2 \ldots n_k$ be the sample sizes ($n_1 + n_2 + \ldots + n_k = N$)
      (iii) Let $d_1, d_2 \ldots d_k$ be the number of defectives found in corresponding samples ($d_1 + d_2 + \ldots + d_k = D$)

Notes

(iv) m = D/n where m = fraction defective

(v) Find n_1p, n_2p … n_kp

(vi) For p < 0.10

Use control limits from respective statistical table else (p >= 0.10)

Calculate control limits by

$$np \pm 3\sqrt{n.p.q} \quad \text{where } q = (1- p)$$

(vii) Test for homogenecity as in (a) for uniform size.

(viii) Accept the 'p' of the homogenecity data as the standard of capability of the process.

Calculation of Process Capability Variable Data

A variable data has two parameters, central tendency and dispersion. Whereas the central tendency can be corrected easily, its very difficult to examine the dispersion and hence is critical for assessing the Process Capability.

Range

1. Let us take number of samples k = 25
2. Let us have n = number of observations in each sample = 4 or 5 (uniform)
3. Let R_1, R_2 … R_k be the 'Range' of sample 1, 2 … k respectively.
4. Average Range $\bar{R}$ = summation $(R_1 + R_2 + \ldots + R_k)/k$
5. Read off the values of D_3 and D_4 from the statistical table against the sample size selected.
6. Then UCL & LCL i.e., Upper & Lower Control Limits are given by $D_4.\bar{R}$ and $D_3.\bar{R}$
7. If no reading is outside the Control Limit, accept $\bar{R}$ as the standard index of process variability.
8. If readings are beyond Control Limits, reject them and find the revised limits and so on till the homogenecity is achieved. In this case the revised Rbar shall be the standard index of process variability.

   Calculate Process Capability by the formula

   Process Capability = $6\,\sigma = 6 \times R / \bar{d}_2$

   where d_2 is from the statistical table against 'n'.

   Variation between samples or the stability of the process.

   This can be checked by examining the consistency of the sample means as given below:

   (a) Calculate sample means of all samples 1, 2, … k.

   Let the sample means be $\bar{X}_1, \bar{X}_2, \ldots\ldots\ldots \bar{X}_k$.

   (b) Calculate the average of the sample averages

   $$= \bar{X} = \frac{\bar{X}_1 + \bar{X}_2 + \ldots\ldots\ldots + \bar{X}_k}{k}$$

Notes

(c) Read value of A_2 from the statistical table

(d) Value of Control Limits for the average are given by

$$\bar{X} + \text{or} - A_2\bar{R}$$

(e) Plot the average on the graph and study the graph carefully for any systematic or other variations of the limits and investigate causes thereof.

Control Charts in Process Control

A Control Chart is the graphical representation between the order of sampling along x-axis and statistics (functions of the observed values of the Variable) along y-axis.

The Central Line (CL) displays the standard line, and UCL and LCL display the Upper Control Limits and Lower Control Limits. These Control Limits (usually 11.7% of the values arising from Chance causes) are used to distinguish between the Chance causes and the Assignable causes of variation. The control charts are useful for operators and hence should be displayed at convenient positions.

Maintenance and Usage of Control Charts

The samples are taken at regular suitable intervals and statistic plotted on a chart. If the point remains within the 'UCL and LCL', the process is allowed to continue. The product so produced is called a good lot.

If there is evidence of lack of control, the process should be stopped, investigated, corrected and restarted. Till the process gets stabilised, keep these goods separately segregated for good and bad separately.

A point outside the control limit is an index of out of control situation whereas the pattern of points indicate the nature of action desired at any point of time.

Types of Control Charts

There are many types of Control Charts suited to various types of situations. The major ones are briefly described below:

1. ***(X, R) charts:***

   (a) (X, R) charts are applicable to variable type of data.

   (b) These charts are used to control the individual characteristic (X, R).

   (c) These charts provide the maximum information from the available data on 'Mean' and 'Variation' for the control.

   (d) Small samples will suffice

Statistic	**Standard**	**Control Limits**	
		UCL	LCL
$\bar{X}$	$\bar{X}$	$\bar{X} + \bar{A}_2 R$	$X - A_2\bar{R}$
$\bar{R}$	$\bar{R}$	$D_4\bar{R}$	$D_3\bar{R}$

where A_2, D_4, D_3 are read from Statistical table against the selected sample size.

Notes

(e) Sampling frequency for (X, R) Charts as per Duncan's study reveal that:

(i) If a shift in the process average causes high rate of loss as compared to cost of inspection, it is better to take small samples quite frequently rather than large samples less frequently e.g., it is better to take 4-5 samples every half hourly rather than 8-10 every hour.

(ii) If it is possible to decide quickly and the cost of looking for trouble is low, then use '2 r or 1.5 r' Control limits rather than 3 r Control limits and use 3 r Control limits if the cost of looking troubles is high.

(iii) If the unit cost of inspection is relatively high, then its better to take sample size of 2 or 3 at relatively long intervals i.e., once or twice in a shift and use Control limits + or 2r (or 1.5 r).

(iv) A Control Chart schedule should take into account detection of changes in process of required degree with desired confidence. However (X, R) charts are not understood easily by Operators/Inspectors and these charts cannot be used for go-on-go type of data.

2. ***p, np chart:*** This chart is applicable to Attribute Data (number of defective units of product)

(a) This chart is used to control the overall fraction defective of a process. The data required for this chart is already available from inspection records.

(b) The chart is easily understood as compared to (X, R) chart.

(c) The chart provides overall picture of the quality. However, this charts does not provide detailed information for Control of individual characteristic. The charts do not recognise degree of defectiveness in units of product standard and limits vary the sample size.

Static	Standard	Control Limit	
np	$n\,\bar{p}$	$np + 3\sqrt{n\bar{p}(1-\bar{p})}$	$np - 3\sqrt{n\bar{p}(1-\bar{p})}$
where $\bar{p} = \dfrac{\text{Total number of defective pieces}}{\text{Number of samples (k)} \times \text{Sample size (n)}}$			

If rejection percentage (p) is < 10 then nm chart is convenient to use with a constant sample size and Control Limits may be read directly from the Statistical Table.

3. ***C chart:***

(a) C chart is applicable to attribute data (number of defects per unit of product).

(b) This chart is used to control the overall number of defects per unit.

(c) This chart gives all the advantages given alone for m-charts. Additionally, it provides the measure of degree of defectiveness in units of product.

However, it does not provide detailed information and control of individual characteristics as in case of (X, R) charts.

Notes

Static	Standard	Control Limits	
		UCL	LCL
C	$\bar{C}$	$\bar{C} + 3\sigma$	$\bar{C} - 3\sigma$
	where $\sigma = \sqrt{C}$		

Having determined C, the Control limit can be directly read from the chart.

Advantages of Control Charts

There are numerous advantages of the Control charts. The alphabets of the 'Control Charts' itself can be used to highlight the advantages of Control Charts:

C Controls the process (at desired Economic levels).

O Optimises technical resources (as it provides the information) as to take remedial action).

N Narrows the heterogenecity (among units of a product).

T Traces differences among Operators, Supervisors, Machines etc.

R Reduces cost of Inspection.

O Overhauling and maintenance of machines, indicated whenever necessary.

L Leads to the detection of inspection errors.

C Creates quality consciousness.

H Histories the process at a glance.

A Acceptability of the product by consumer is enhanced.

R Reduces waste of materials.

T Trains the Operator and improves his skill.

S Standardises the stage processes.

6.6 Emphasis from Quality Control to Quality Assurance

"Quality is never by an accident,

It is always the result of an intelligent effort".

– *John Ruskin*

"Quality is never by an accident,

It has always to be pre-planned".

– *Juran*

The quest for efficiency is eternal to mankind. In industrial parlance, efficiency means maximising production of quality products at optimal cost.

Quality has been defined in different ways by different persons, such as:

1. Degree of Excellence
2. Life of Product
3. Cost of Product

Notes

4. Fitness for use
5. Conformance to requirements
6. Customer's satisfaction

These need based definitions represent only certain facets of quality. The achievement of satisfactory quality involves all stages of the quality loop as a whole e.g.,

1. Quality due to definition of needs (as defined above)
2. Quality due to product design
3. Quality due to conformance and product support throughout its life time

Notes **Quality Loop**

From this it is evident that quality cannot be built into the product during manufacturing alone and instead it has to be built into the product right from the stage of assessing the marketing conditions to design, procurement, manufacturing, sales and distribution and finally after-sales-service to the customer.

The concept has led the industry to shift emphasis from Quality Control (QC) to Quality Assurance (QA) and ISO: 9000 System is the outcome of the quest of the industry to meet challenges of technology upgradation and ever increasing competition in the International market.

6.7 ISO: 9000 Standards

ISO stands for International Organisation for Standards. ISO: 9000 is a series of international standards for quality systems. It is a practical standard for quality applicable both to the manufacturing and service industry.

These standards were first published in India in 1987 and subsequently revised in 1994. These standards have made a dramatic impact on business around the world and have become the regular (a must) for doing business in the world market.

Did u know? Indian, British and European Equivalent Standards are:

INDIAN	:	IS: 9000
BRITISH	:	BS: 5750
EUROPEAN	:	EN: 29000

ISO: 9000 sets out that the company can establish, document and maintain an effective and economic quality system which will demonstrate to the customers that the company is committed to quality and is able to meet their quality needs. These standards answer concisely:

ISO: 9000	:	What is Quality Management?
		How to sum a Quality Assurance System ?

Notes

ISO: 9001
ISO: 9002
ISO: 9003

These systems (9001-9003) describe about the quality aspects covered and are known as module-1, module-2 & module-3 respectively.

ISO: 9004 : What sort of Quality Operations are appropriate to a Project?

These are internationally accepted standards and laid down in an organised way. The standards have been split into 20 Sections (called Elements) to enable users to implement it easily, effectively and efficiently (3 e's). They provide an opportunity to have a complete record of all the 20 elements, based on their company standards for use within their own industry. The standards have been written in general terms with the Product manufacturer in mind but the standards are equally applicable to the service industries such as banking, hospitals, hotels and restaurants, educational institutions etc.

Standards under ISO: 9000 System

ISO: 9000 Quality Management and Quality Assurance Standards Guidelines for Selection and use of modules.

ISO: 9004 Quality Management and Quality System Elements – Guidelines for 20 Elements.

ISO: 9001-model 1 - Model for quality assurance in design/development, production, installation and servicing.

ISO: 9002-model 2 - Model for quality assurance in Production and Installation.

ISO: 9003-model 3 - Model for quality assurance in Final Inspection and Testing.

ISO: 9000 (Quality Management)

1. This standard provides the essentials of putting a Management of Quality Assurance Policy action.
2. It clarifies the relation between different quality concepts and specifies the rules for using the three models given in ISO: 9001, 9002 and 9003.

   ISO:9004 (Quality Management and Quality System Elements Guidelines)
3. Consists of an examination of the quality system elements cross-referenced in ISO: 1000 and the system standards. A manufacturer needs to understand an operation in sufficient detail so that only the appropriate elements are selected for each stem of the operation. The object is to minimise cost of the quality project while maximising the benefits.

Three Quality Assurance Models

Model One (ISO: 9001)

Model one is for use when conformance to specified needs is to be assumed by the manufacturer throughout the whole cycle from design to servicing. Model one represents the fullest requirement involving all the quality system elements in ISO: 9004 at their most stringent.

Model Two (ISO: 9002)

Model two is more compact. It is for use when the specified requirements for products are started in terms of an already established design or specification. Only the suppliers capabilities in production and installation are to be demonstrated. Here again all the elements of ISO:9004 are present, but some are treated less stringently.

Notes

Model Three (ISO: 9003)

Model three applies to situations where only the suppliers' capabilities for Inspection and Testing can be satisfactorily demonstrated.

In this model, only half of the quality system elements of ISO: 9004 are required and at a lower level of stringency than model two.

Salient Features of ISO: 9000

ISO: 9000 helps in fixing responsibility:

1. A company adopting ISO: 9000 series must identify and assign responsibility for all functions that affect quality. The aim of company shall be to achieve, sustain and improve the reputation for 'quality' at competitive prices in the national and International markets. For achieving this aim, the responsibility and commitment to quality belongs to the management. An executive with necessary authority and ability must be put incharge as 'Management Representative' (MR) and his job would be to co-ordinate so that requirements of ISO 1000 are met. He must accord the buyers' representatives all the facilities listed in the contract and allow him reasonable access to the company records and procedures (Management Responsibility).
2. The supplier shall establish and maintain a documented quality system as a means of ensuring that product conforms to specified requirements. This shall include:
   (a) The preparation of documented quality system, procedures and instructions in accordance with the requirements of the International Standard.
   (b) The effective implementation of the documented quality system procedures and instructions (Quality Policy).
3. The supplier shall establish and maintain procedures for contract review.
4. The supplier shall establish and maintain procedures to control all documents and dates that relate to the requirements of this International Standard. These documents shall be reviewed and approved for adequacy by authorised personnel prior to issue (Documents & Data Control).
5. The supplier shall ensure that purchased product conforms to specified requirements.
6. The supplier shall establish and maintain procedures for verification, storage and maintenance of purchased supplier product provided for incorporation with the supplies.

   (e.g., Rolling-mill for a mini steel plant project).
7. Where applicable and appropriate, the supplier shall establish and maintain procedures for identifying the product from applicable drawings, specifications or other documents, during all stages of production, delivering and installation.

   (Identification of Product)
8. The supplier shall ensure that all processes are carried out under Controlled Conditions.

   (Process Control). The supplier shall ensure that:

   (a) The incoming product is not used or processed until the same has been inspected or otherwise verified (Raw Materials Inspection).

(b) The product is being inspected and tested as per quality plan during all stages of production (Inspection and Testing).

(c) The supplier shall carry out all final inspection and testing in accordance with the quality plan or documented procedures (Inspection & Testing).

9. The supplier shall control, calibrate and maintain inspection, measuring and test equipment, whether owned by the supplier or provided on loan by the purchaser.

   (Inspection Measuring and Test Equipment)

10. The identification of inspection and test status shall be maintained, as necessary, throughout production and installation to ensure that only the product that has the required inspection and test is despatched.

    (Inspection and Test Status)

11. The supplier shall establish and maintain procedures to ensure that product which does not conform to specified requirements is prevented from inadvertent use or installation.

    (Control of non-conforming product)

12. The supplier shall establish, document and maintain procedures for investigating the case of non-conforming product and the corrective action needed to prevent recurrence and also suitable measures to rectify the procedures and processes to prevent recurrence.

    (Corrective action)

13. The supplier shall establish, document and maintain procedures for handling, storage, packaging and delivery of products.

    (Handling storage, packaging and delivery).

14. The supplier shall establish and maintain procedure for identification, collection, filing, storage, maintenance and Quality Records.

    (Quality Records)

15. The supplier shall carry out internal quality audits to verify whether quality activities comply with planned arrangement and to determine the effectiveness of the quality system.

    (Internal Quality Audits)

16. The supplier shall establish and maintain procedures for identifying the training needs and provide for the training of all personnel activity affecting quality during production and installation. Appropriate records of training shall be maintained.

    (Training)

17. Where appropriate, the supplier shall establish procedures for identifying statistical techniques required for verifying the acceptability of process capability and product characteristics.

    (Statistical Techniques)

    ISO: 9000 can be summarised as

The ISO: 9000 series of standards are basically Quality Assurance Standards and not product standards. The series of standards aims at the following:

1. Increased customer confidence in the company.

2. A shift from a system of inspection, to one of quality management (QC–QA).

Notes

3. Gaining management commitment (as quality policy is by top management).
4. Looking quality from cost consciousness point of view.
5. Giving customers what they need (Contract system).
6. Removing the need for multiple assessment of suppliers.

The implementation of ISO 9000 as described above clearly indicates that ISO:9000 is a stem towards TQM (Total Quality Management).

Implications of ISO: 9000 for India's Export

The world share is being controlled today by the European Union (consisting of members at present–Germany, France, Belgium, Italy, Netherland, Denmark, United Kingdom, Ireland, Greece, Portugal, Spain, Sweden, Austria and Finland), the USA and the Japan.

These European Union countries have circulated the following list of products which have to be procured only from the exporters having ISO 1000 or its equivalent Certification.

We have been having a good amount of share from these countries and hence can ill-afford to lose this market. We, therefore, have to have ISO Certification at the earliest to continue to have benefit of our good business relations with these countries. This will also help us to improve our quality and we shall be able to withstand competitors from foreign countries operating within our country & also to compete with them for International market.

List of Products where Compulsory ISO 9000 Certification is Required in Europe

1. Toys
2. Simple Pressure Vessels
3. Gas Appliances
4. Personal Protection Equipments
5. Machinery
6. Upholstered Furniture
7. Ski Lifts (Lifting Equipments)
8. Marine Equipments
9. Children Playground Equipment
10. Medical Diagnostic Kits
11. Temporary Structures (e.g. Scaffoldings)

Differences between ISO:9000 and ISI Marking

ISO:9000 is a Quality System Standard and not a product standard i.e. a company having an ISO: 1000 certification shall not automatically be qualified for its Product Standards.

A customer requiring a product with ISI mark from an ISO company has to be provided with a product with ISI mark as usual conforming to a particular specification and not that the company can escape this responsibility.

A company can produce variety of products out of which not necessarily all should have ISI mark but for an ISO company they have to adhere to uniform standards (System Standards) as per ISI system for all products.

Further, the ISI mark is by BIS only whereas the certification for ISO standards can be had from any of the authorised agencies in India or abroad. (Today, more than 10 agencies are serving in India itself.)

The product standard can be put on the product but not the ISO. The ISO system, however, can be displayed through letter head, paper advertisement, magazines and other media.

How to obtain Licence?

Stage I: Application and its Processing

1. Firms interested in obtaining licence for quality system as for IS/ISO: 1000 family or Standards, should ensure that they are operating quality system in accordance with relevant standard.
2. They should apply on the prescribed proforma in .....(Form III) at the nearest regional office of BIS (or any other credited agency) alongwith prescribed application fee as applicable (The schedule of fee is given here below).
3. The application is to be signed by the proprietor, partner or the Chief Executive Officer (CEO) of the firm or other person authorised to sign any declaration on behalf of the firm. The name and designation of the person signing the application must be recorded legibly in a space set apart for the purpose in the application form.
4. Each application must be accompanied by a supplementary questionnaire (Form IV) duly filled in alongwith the, Documented Quality System the requisite of the relevant quality system standard.

If the application is rejected by BIS

Reasons shall be given therein:

1. Application Fee not accompanying the application.
2. Application Form III or IV is incomplete.
3. Annexures to the application are not clear.

BIS will acknowledge the receipt of application/application fee. Every applicant will be given a serial number to be known as "Application Number".

In all future correspondence, reference of Application Number is a must.

Stage II : Adequacy Audit

1.. After the application has been accepted, the Documented Quality System (Quality Manual/ Quality Plan etc.) shall be examined by the BIS for verifying the conformance to relevant standard (001/002/003).

2. Any significant omission or deviation from the prescribed requirements situated by BIS will have to be corrected by the applicant.

Notes

Stage III : Preliminary Visit & Assessment

BIS official(s) may make a visit to the premises of the applicant to acquaint himself/themselves of the size, nature of operation & firm's readiness for the audit. The assessment will comprise the following sequence:

1. ***Opening Meeting:*** The meeting will be conducted by the leader if the audit team in which the CEO of the company, MR (Managerial Representative) and Heads of all departments being audited are expected to be present.

   During this meeting, the leader will explain the scope and extent of the audit and the important terms used in the audit.

2. ***Conduct of Assessment:*** Each auditor should be accompanied by a guide who is conversant with the activities of the deptt(s). The auditor is auditing.

   Observations recorded by the auditors must be signed by the guide as a token of acceptance.

3. ***Closing Meeting and Report:***

   (a) All the members present in the opening meeting should preferably be present in the closing meeting as well, when the audit team will present their findings to the firm.

   (b) The non-conformities (as ..... to established system) observed by the audit team will be handed over to the firm at the end of each day for necessary corrective action.

   (c) These frames for the corrective action(s) will be decided by the firm.

   (d) The non-conformity report will be signed by the Managerial Representative who is the manager, agent or representative for the Quality Implementation System as a token of acceptance.

Responsibility of Applicant during the Audit

The firms expected to provide the following assistance to the audit team:

1. Arrangement of stay/local guidance and travel agents etc.
2. CEO & MR must be present during the opening and closing meetings. As far as possible all head lines audited.
3. In the interest of the firm all effort should be made that the time of audit team is not wasted on account of relevant personnel, document, record, being audited.
4. The firm will arrange a place or room where members of the audit team can meet and discuss during the day and at the end of the day to exchange their notes and findings.

6.8 Grant of Licence

1. Before the licence is granted, corrective actions taken by the firm on the non-conformities observed during the audit will have to be verified by BIS.
2. The applicant shall give the following undertaking and we shall make no claim direct or implied that the licence to be granted relates to any product or processes other than those that will be set out in the licence and schedule.
3. Based on the findings of the Audit Team and Satisfactory report, the firm will be granted a licence by BIS.
4. The licence shall be granted for a period of three years.

5. Grant of licence will be followed by survillace visits, once in six months by the author(s) of BIS to verify the effective implementation & maintenance of the quality system established by the firm.
6. During the operation of the licence, if the licencer fails to observe the creditors of the Quality System Certificate Scheme the licence of the firm is liable to be suspended and may call for special visit for which firm is liable to pay special visit charges, as per schedule of fees.

Renewal, Deferment, Expiry and Cancellation of Licence

1. Any licence granted to 3 years expires automatically at the end of three years.
2. A renewal notice will be issued by BIS at least four months before the expiry of the current operating period.
3. The Licence is required to submit the Renewal Application alongwith the original copy of the licence atleast three months in advance, before the expiry of the licence.
4. The Renewal Application will be followed by a complete audit of quality system of the firm.
5. If any discrepancies/non-conformities are observed during the audit, the licence will be to take corrective action.
6. After the Licence taken necessary action to remove discrepancies, the Quality System of Certification Licence will be renewed for period of three years.

Privileges of Licensee

The privileges enjoyed by BIS licensees include:

1. Original Quality System Certification Licence which can be demonstrated by the licensees to anyone concerned. If need be, it can be photocopied & displayed at various locations.
2. A very attractive plaque containing details of certification is presented as a compliment at the time of award of certificate. Additional plaques can be provided by BIS on actual cost payment basis.
3. Use of Quality Systems Certification mark, on letter heads in advertisements, brochures, complementaries & for other promotional purpose. Standard Mark, . . ., shall not be directly marked on the product and its packaging (As Product is not certifying this mark, but the System).
4. Each licence shall be listed in the register monitored by BIS. ISO 9000 Standards.

6.9 Statistical Quality Control (SQC)

Statistical Quality Control is the application of statistical techniques to determine how far the product confers to the standards of quality & precision and to what extent its quality deviates from the standard quality.

Techniques of SQC

1. Quality Control during Production;

   By Control Charts in Process control.
2. Quality Assurance while Purchasing;

   By Acceptance Sampling for the Incoming materials.

Notes

Quality Control during Production

The Standard Quality is determined through careful research & investigation. It is quite impracticle to adhere strictly to the standards of precision, especially in cases where human factor dominates over the machine factor. Some deviation is therefore, allowed or tolerated. They are referred to as tolerances. Within the limits, set by these tolerances, the product is considered to be of standard quality. SQC brings to light the deviations outside these limits, i.e. the purpose of Statistical Quality Control is to discover and correct only those forces which are also responsible for variations outside the suitable pattern through SQC techniques.

While acceptance through sampling is used for controlling the materials input to the process, the process itself may be controlled by Statistical Sampling procedures i.e. by taking samples from the output of the process. The samples may be checked for:

1. Their measurable characteristics such as length, diameter, hardness, tensile strength etc.
2. 'Fraction Defectives' "p", when the characteristics cannot or need not to be measured.
3. Number of defects in the sample (c).

The Process is said to be within control if the sample points fall within the pre-established control limits. The crux of the Process Control lies in establishing the appropriate control limits. The charts showing these control limits are called 'Process Control Charts'.

Kinds of Process Control Charts

1. Sampling means chart (x);
2. Fraction Defections charts or 'p' chart; and
3. Number of Defects chart or 'c' chart.

Problems on Control Charts

Example: Draw the control charts for X (mean) and R (range) from the data relating to 10 samples, each of size 5.

Sample no.	X	R
1	3.456	0.012
2	3.467	0.056
3	3.385	0.021
4	3.380	0.045
5	3.387	0.028
6	3.450	0.058
7	3.560	0.018
8	3.670	0.035
9	3.577	0.023
10	3.213	0.067

Values for (n = 5) $A_2 = 0.577$

$D_4 = 2.115$

$D_3 = 0$

Solution: **Notes**

k = Number of samples = 10

n = Number of observations in each sample = 5

$\bar{X} = \Sigma X/10 = 34.545/10 = 3.4545$

$R = 0.441/10 = 0.0441$

For $\bar{X}$ chart

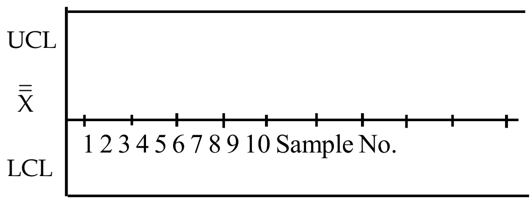
$$UCL = \bar{\bar{X}} + A_2 \text{ X } \bar{R} = 3.4545 + 0.577 \times 0.0441$$
$$= 3.48$$

$$LCL = \bar{\bar{X}} - A_2 \text{X } \bar{R} = 3.4545 - 0.577 \times 0.0441$$
$$= 3.43$$

For R chart

$$UCL = D_4 \times \bar{R} = 2.115 \times 0.0441$$
$$= 0.013$$

$$LCL = D_3 \times \bar{R} = 0 \times 0.0441$$
$$= 0$$



Example: Draw the control charts for X (mean) and R (range) for the above example with the following information:

For n = 5, $d_2 = 2.326$

$d_3 = 0.864$

Solution:

$\bar{\bar{X}} = \bar{X}$ / 10 = 34.545/10

= 3.4545

= 0.441/10 = 0.0441

For $\bar{X}$ chart

$$UCL = \bar{\bar{X}} + 3 \times \bar{R} / (d_2 / \sqrt{n})$$
$$= 3.4545 + 3 \times 0.0441/(2.326 / \sqrt{5})$$
$$= 3.4545 + 0.1268$$
$$= 3.5813$$

$$LCL = \bar{X} - 3 \times \bar{R} / (d_2 / \sqrt{n})$$
$$= 3.4545 - 3 \times 0.0441 / (2.326/\sqrt{5})$$
$$= 3.3277$$

Notes

For R chart

$$UCL = R + 3 \times \sigma_R$$
$$= 0.0441 + 3 \times (R / d_2) \times d_3$$
$$= 0.0441 + 3 \times (0.0441/2.326) \times 0.864$$
$$= 0.0441 + 0.0411$$
$$= 0.0132$$

6.10 Acceptance Sampling

Acceptance Sampling can be described as the post-mortem of the quality of the product that has already been produced. The term Acceptance Sampling 'relates to the acceptance of a consignment/batch of items on the basis of its quality.' It is used for:

1. Acceptance/rejection of the raw-material delivered.
2. Passing/non-passing of the batch of items manufactured.
3. Shipment of items for delivery to customer.

How an Acceptance Sampling Operates?

If for instance from a consignment or a batch of 'N' items, a sample of size 'n' is taken, in which 'c' or less number of items are found defective, then the consignment or batch gets accepted if more than 'c' items are found defective, the entire consignment/batch is rejected.

Thus, the inference or decision regarding a large quantity (or population) of n items is made on the basis of a sample quantity(n).

Here (N,n,c) as a set, constitute the sampling plan, called Sampling Plan Attributes.

Risk Involved

With any sampling plan, there is always a risk:

1. Very bad lots will be passed.
2. Good lots will be rejected.

These two risks are appropriately called Consumer's Risk and Procedure's Risk respectively.

Operating Characteristic Curve (or OC Curve)

We can plot a curve between the % defectives in the lot and the probability of acceptance of the lot, under any given sampling plan known as the OC curve.

The procedure sends a lot of Acceptable Quality Level (AQL), (given in percent defectives) which can get rejected, the chance or probability of this being the Procedures Risk (PR), whereas on the other hand the customer (manufacturing plant) faces the risk of accepting lots as bad as the LTPD (Low Tolerance Percent Defective), the probability of acceptance of such lots being the Consumer's Risk (CR). The probability of acceptance can be determined by making use of the following expression which is found on Hyper exponential distribution:

$$P(a) = 1 - \sum_{b=0}^{b=b} P(b)$$

Notes

$$P(b) = \frac{C_b^B \; C_g^G}{C_n^N}$$

where,

P(b) = Probability of finding 'b' number of bad items in the sample of size 'n' taken from the lot of size N

B = Number of bad items in the lot;

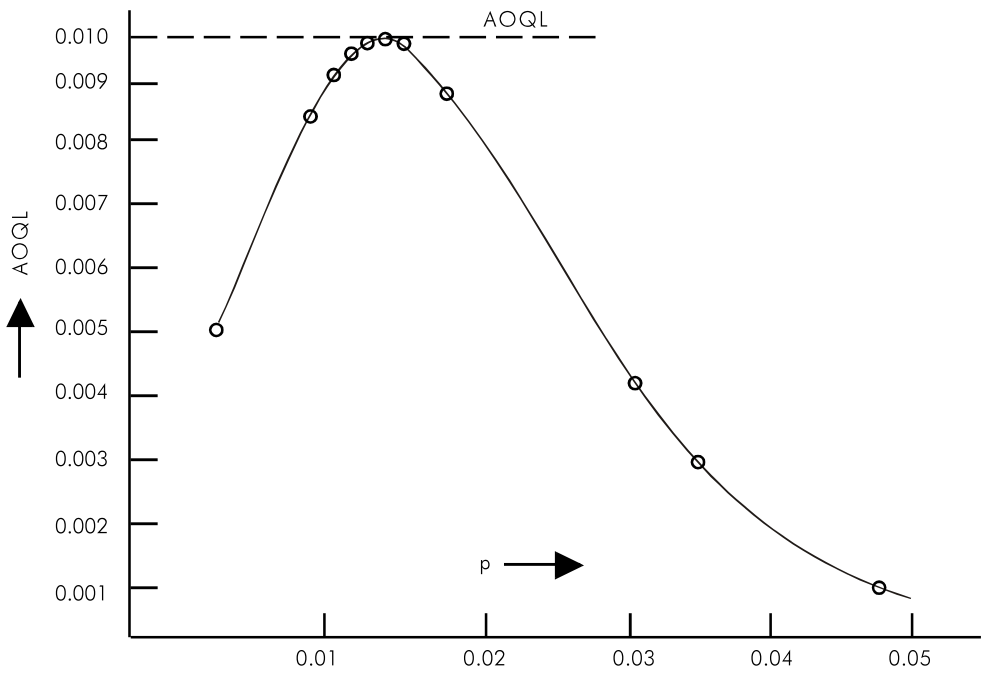
G = Number of good items in the lot;

g = Number of good items in the sample;

b = Number of bad items in the sample;

P(a) = Probability of Acceptance of the lot.

Figure 6.2: Operating Characteristic Curve



6.11 Importance or Benefits of SQC

The technique of SQC has become very popular since the days of World War II. In modern Industry it has become a necessity as it offers the following benefits:

1. ***It saves on rejection:*** In the absence of SQC technique, many products may be found defective and worthless at the of manufacturing process and have to be thrown away as a scrap. SQC helps to avoid such a situation and thus saves the cost of labour & material involved in the production of defective items.

   SQC technique measures the extent of defect and certain defective products may be approved with reworking to the level of acceptable standards. It helps in deciding whether to do reworking or not and hence helps in reduction of loses due to unnecessary working.

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2. ***It maintains high standards of quality:*** The SQC technique as described above (though Control Charts and Acceptance Sampling Techniques) helps in removing rejections and/ or by improving through reworking whether felt necessary and hence the outgoing standard is quite higher as compared to in the absence of SQC Technique. This increases the goodwill of the company which gives intangible benefits.
3. ***Reduces expenses of inspection:*** It reduces the expenses of as lot size to be inspected is very small as compared to 100% inspection and thus enables the product to be manufactured at lower cost.
4. ***Ensures standard price:*** As the outgoing quality of the product is a standard/uniform, hence the producer is able to secure the standard price for all standard products. Thus, it increases the profitability of the concern.
5. ***Feeling of responsibility among the workers:*** Among the workers a feeling of responsibility develops because they begin to understand that their work is being inspected very minutely, hence they work carefully and it helps in increasing their morale.
6. ***Reduces monotony & unnecessary fatigue of inspection:*** As 100% inspection is very monotonous and is likely to cause unwillingness at the part of quality inspection, thus SQC which is a technique implying sampling/acceptance plans is not monotonous & hence helps in reducing their unwillingness & increasing degree of quality.

6.12 Human Behaviour in Managing Quality

Human Aspects of Quality Assurance

Organisational commitment to quality has to be developed through the powers of education the persons involved i.e. the people who make up the organisation. It is immaterial whether the education process is carried through formal training or through participation in programs such as 'Quality Circle'.

The education will be aimed at:

1. Commitment to quality by everyone right from the level of the messenger/worker to chairman/M.D. of the organisation.
2. Enabling the employee to perform his role efficiently (thus quality circle or JIT concept) and promoting his interactions with other employees.
3. Developing the systems and procedures for quality gestation & maintenance Quality management is no more for the product certification.

   (ISI -Certificate) but it is for the System Certification thus systems like ISO-1000 etc. Hence:

   QC $\rightarrow$ QA i.e. Quality Control to Quality Assurance through Quality System like ISO-9000/14000 is a step towards TQM i.e. Maximization of quality products achieved at optimal cost.

6.13 Total Quality Management (TQM)

TQM is a quality-focused customer-oriented integrative management method that emphasises continuing and cumulative gains in quality, productivity and cost reduction. These gains are achieved through continuous improvement in product design, reduction in operating costs, reduction in operating losses, avoidance of wastage of time, effort and material in an form, removal of production-line deficiencies, upgradation of skills and empowerment of employees

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to detect and correct errors, among other measures. TQM involves the participation of every department, every section, every activity, continuous improvement effort. Its central integrative focus is the concept of total customer satisfaction with the quality and performance of the company's products or service.

The structure of TQM may be seen to consist of the following main elements:

1. Design Standardisation
2. Taguchi Methods (Control of Variability)
3. Quality Function Deployment
4. Performance Measurement and Statistical Quality Control
5. Employee Involvement
6. Small-Group Activities

The nature of each of these elements may be outlined briefly:

1. ***Design standardisation*** denotes that the design of components and their assembly in a product has been rationalised, tested rigorously and proven in manufacture. It is a powerful means for improving the flow of new products through the product and process design function. It also has major implications for simplifying the factory floor environment and the entire product service task in the field. A proven standard design serves to eliminate various 'bugs' from the production process. It makes possible the optimisation of the production process and its error-free operation.
2. ***Taguchi methods*** provide a powerful means for isolating critical product design parameters that need to be controlled in the manufacturing process. They also enable manufacturing management to relate the variability in their products to monetary losses. Taguchi's quality loss function enables management to think of quality in terms of money rather than merely in terms of the implications of various statistical distributions, standard deviations, variability and so on. The importance of Taguchi methods lies in their demonstration of how the cost of variability. The cost of quality to the company and to society can be calculated through Taguchi's quality loss function.

Example: The function, enables a company to evaluate the significance of a 50 per cent reduction in product variability in terms of monetary gains. The company can then analyse whether the methods by which it can achieve that 50 per cent reduction in variability are worth the reduced quality monetary losses.

3. ***Quality Function Deployment (QFD)*** represents a comprehensive analytic schema or framework for quality. The purpose of this schema is to enable a company to translate any customer preference or desire about products into what has to be done in design, manufacturing or distribution and to the product and the process, to satisfy the customer.

   Quality function deployment provides structure to the product development cycle. The foundation of this structure is customer requirements. QFD proceeds in a systematic manner from design concepts to manufacturing process to manufactured product. It ensures at each step that quality assurance is built into both process and product. QFD also implies that the company has documented its quality policy that is understood, implemented and maintained at all levels in the organisation and that responsibility and authority are clearly defined.
4. ***Performance measurement and statistical quality control*** are applicable to both the factory of the enterprise and its vendors or suppliers. The latter are enjoined upon and expected to supply materials, components and inputs of required standards and specifications of quality.

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Without a proper frame of measurement, a company cannot assess and evaluate the success or effectiveness of its efforts towards improving the cost and quality of its operations and outputs.

5. ***The concept of employee involvement*** is essentially concerned with extending decision-making to the lowest possible hierarchic level of the company. It also denotes a high level of workers' motivation and morale and their identification with the goals of the organisation. A high level of employee involvement, i.e., their motivation, commitment and empowerment towards productivity, innovation and problem-solving, depends on the strength of an organisation's culture, i.e., its system of shared values, beliefs, norms and vision.

6. ***The concept of small-group activities*** is closely aligned with employee involvement. Small voluntary groups of workers known as quality circles or productivity teams represent a mechanism for evoking, sustaining and utilising employee involvement. Small-group activities represent a powerful way of improving productivity, quality and work performance in the organisation in a continuing manner.

Six Sigma or Zero Defects in TQM: Six sigma is a major part of the TQM programme. It is defined as 3 to 4 defects per million. It stresses that the goal of zero defects is achievable. The concept and method of six sigma is applicable to everyone and to all functions, i.e., manufacturing, engineering, marketing, personnel, etc. As a concept, it aims at reducing process variation and reducing and finally eliminating all defects. As a method, it aims at the output of work, the customers of that output, customers' critical requirements, suppliers and the firm's critical requirements of them, the processes used by the firm and the tools and approaches for continuously improving the firm's processes. Six sigma, in essence, is a measure of variation.

Methodology of Six Sigma

The application of six sigma as a concept and a method involves the following six steps:

1. Specify clearly the products or services, i.e., the output, you provide. These include output from your processes that the customer receives from you and which incorporate your value-added element.
2. Specify the customers of the output and determine what they consider important.
3. Identify your suppliers and specify your critical requirements of them. Your ability to satisfy your customers depend on the ability of your suppliers to meet your critical requirements.
4. Delineate the process for doing your work. Map key sub-processes or activities and identify tasks, decision-points, storage points, wait points or queues, workflow and items of rework.
5. Examine each link or step in the process with a view to assess whether or not it adds value to the product or service to satisfy the customer. Improve the process in the light of such an examination.
6. Continue the improvement process by measuring and analysing defects or deficiencies and then proceed towards removing them in a planned manner.

Integrative Focus of TQM

The TQM system is integrated around the central concept of Total Customer Satisfaction. The concept is not restricted to the manufacture of zero-defect products. It extends to and encompasses continuing changes or improvement in the product based on feedback from the customers regarding their preferences and expectations regarding the performance of the product. This aspect is also known as the practice of 'experience or design looping' in Japanese firms. It essentially implies continuing improvements in products' design and manufacture in the light of periodic surveys of customer experience, opinions and preferences.

Key facets of TQM's integrative focus are the four PIs:

1. People Involvement
2. Product Process Innovation
3. Problem Investigation
4. Perpetual Improvement

The keynote of these four PIs is teamwork or cooperation. In TQM, however, the concept of teamwork is larger and more inclusive. It implies that (a) employees are viewed as assets; (b) suppliers are viewed as partners; and (c) customers are viewed as guides. Involving all three of them intimately in the company's team effort to accomplish TQM is a continuing thrust of the company's manufacturing policies.

The underlying assumptions or key premises of TQM may be briefly summarised:

1. Quality cannot be improved by investment in high technology alone.
2. Quality depends on and comes from, people.
3. Quality is the result of attitudes and values; it is the result of viewing quality as a 'way of life'.
4. Organisational culture and management style govern the quality of products and services in a very basic manner.

Task Give example from an organisation about the role played by human behavior in managing quality.

6.14 Determinants of Quality

Quality, quality management, quality control, etc. are not functions but products of sound management. Principles and effective management of design, are – scope, specification, documentation, cost, budgets and time. From inception to the completion of a construction project, each function must be aimed at the achievement of quality, whether the function is design, specification, documentation or procurement. Furthermore, the element of competition and what it purports to achieve, must not be forgotten.

The traditional approach to competitive tendering involves the calling of tenders addressed to a principal, which purports to carry out specified work and/or the supply of goods in return for specified payment. In the evaluation of the tenders, the principal will seek a tender that best suits the specific requirements of price, time and quality. From time to time, other criteria may also apply. In recent South African experience, tenders submitted to the various state bodies might also be evaluated on the basis of:

1. Affirmative action
2. Training
3. Labour content
4. Local materials
5. Community involvement.

The appointment of professionals may also be classified as 'competitive' as the consultant team should be able to produce a product meeting standard levels of acceptability, manage the process and motivate the contractor to achieve the highest levels of quality.

Taking the foregoing into account, the generation of quality products in construction is influenced by the following determinants:

1. Budgets
2. Development cost plans
3. Design and design management
4. Specification
5. Documentation
6. Communication systems
7. Total cost management and control
8. Time scheduling and time management.

Quality is inherent in each of these processes, which should not be reactive, but rather inherent in dynamic and proactive management of quality-achievement. At the risk of subordinating the purposes and interests of those who use and live in buildings, professionals, consultants, developers and contractors must realize the needs of the market, the people and the community they serve. The danger is that through "conceptual frameworks we risk isolating fragments of social reality, decontextualising, then recontextualising and, in so doing, creating a different kind of world". In the final analysis, quality can only be achieved in a specific context, within a specific environment, for a real community.

The determinants of quality are of importance to operations academics and managers, and they provide the identification of the determinants of service quality. There are some quality determinants that are predominantly satisfiers and others that are predominantly dissatisfiers. It is found that the predominantly satisfying determinants are attentiveness, responsiveness, care and friendliness; and the dissatisfiers are integrity, reliability, responsiveness, availability and functionality. Responsiveness is identified as a crucial determinant of quality as it is a frequent source of satisfaction, and the lack of it is a major source of dissatisfaction. Contrary to the existing literature, shows that the causes of dissatisfaction are not necessarily the obverse of the causes of satisfaction and, furthermore, that reliability is predominantly a source of dissatisfaction not satisfaction.

Further, determinants of quality include the management activities of "control", "improvement" and "the rest". Using various examples, the use of people and data are explained in the management of control and improvement. It is concluded that if companies are to improve their service/ product's quality, they must review the needs for improvement of data collection and presentation and the quality skills needed at all managerial levels.

With the recent growing interest in service relationships in the industrial sector, a need exists to investigate the underlying determinants for service quality for business-to-business service encounters.

Example: ***Here is an example of the determinants of quality needs in the case of childcare:*** There is consensus around the world that young children must experience high quality services, not only to ensure the best possible future outcomes, but because children have the right to the best possible present. All children are found to benefit from high quality early childhood programs, but those from disadvantaged backgrounds demonstrate stronger advantages. The catchphrase 'the importance of the early years' has now become a call to arms: it is recognised worldwide that we must provide the best possible services to young children and their families.

However, there is not universal agreement as to what constitutes best possible early childhood services. Understandings of quality are value-based and change as values change. (Childcare Resource and Research Unit 2004).

Understandings are also different across cultures, religions, contexts and the person or group making the judgment. Myers (2004, p.19) argues that 'different cultures may expect different kinds of children to emerge from early educational experience and favour different strategies to obtain those goals'. There is not a universal definition of quality: in different times and places different kinds of practices are valued as high quality.

Despite this, within the Western world, professionals assume at least a basic common understanding. The European Commission Childcare Network attempted to define these commonalities and came up with 40 quality targets. Analysing the literature from a range of European countries, Myers (2004) argues there is consensus around quality components including safety, good hygiene, good nutrition, appropriate opportunities for rest, quality of opportunity across diversity, opportunities for play, opportunities for developing motor, social, cognitive and language skills, positive interactions with adults, support of emotional development, and the provision of support for positive peer interactions. However, performance indicators identifying how these principles play out in practice differ in different contexts and with different levels of expectations and resources.

What is clear is that quality is multidimensional, complex and multi-theoretical. Single indicators of quality are ineffective, as quality outcomes for children are found to relate to a complex interplay of many different factors. In this context of complexity and uncertainty, researchers attempt to measure quality, and states attempt to regulate for quality care. Research tools measuring quality tend to focus on particular theoretical approaches to learning, for example the developmentally appropriate practice approach. At state level, regulations are introduced addressing certain easily measured aspects of care. There is general agreement that where regulations are strict, quality is enhanced and outcomes for children are better, so the assumption remains that regulations must be doing some good. O'Kane (2005) agrees, arguing that regulations contribute to enhancing quality practice, but they are not solely responsible as there are a number of other factors coming into play.

S.No.	Quality Dimensions	Description
1.	Performance	A product's primary operating characteristics. For example, in a television set performance means sound and picture clarity, color, and the ability to receive distant stations. In services, such as airlines, performance often means prompt service.
2.	Features	The bells and whistles of a product – the secondary aspect of performance. Examples include free drinks on a plane.
3.	Reliability	The probability of a products surviving over a specified period of time under stated conditions of use.
4.	Conformance	The degree to which physical and conformance characteristics of product match pre-established standards. Example is the tolerances on machined parts.
5.	Durability	The amount of use one gets from a product before it physically deteriorates or until is replacement is preferable.
6.	Serviceability	The speed, courtesy, and competence of repair. It refers to how readily and easily the product is repaired when it fails.

Contd...

7.	Aesthetics	How a product looks, feels, sounds, tastes or smells. This is clearly a matter of personal judgement, and will vary from one customer to another.
8.	Perceived quality	Subjective assignment resulting from image, advertising, or brand names. Consumers do not always have complete information about a product or service. A product's durability, for example, cannot be readily observed-it must be inferred from various tangible and intangible aspects of the product. In this case, images, advertising, and brand names – inferences about quality rather than the reality itself – can be critical. The customer impression of quality is the essence of perceived quality.

Example:

Dimensions of Quality

Dimension	Product example: Stereo amplifier	Service example Checking account at a bank
Performance	Power-	Time to process customer requests
Features	Remote control	Automatic bill paying
Reliability	Mean time to failure	Variability of time to process requests
Durability	Useful life (without repair)	Keeping pace with industry trends
Serviceability	Modular design	On-line reports
Response	Courtesy to dealer	Courtesy to teller
Aesthetics	Oak-finished cabinet	Appearance of bank lobby
Reputation	Market leader for 20 years	Endorsed by community leaders

6.15 Contribution of Quality Gurus

Walter A. Shewhart (1891-1967)

Born in Illinois, USA, Shewhart graduated University of Illinois and then he obtained the doctorate in physics at University of California in 1917. Working at Western Electric Company as an engineer, he was able to make a serious contribution to a major problem: reliability of the equipment buried underground. Control charts created by him were use to differentiate between assignable sources of variation and pure chances of variation. Shewhart studied randomness and recognized variability which exists in all manufacturing processes. In his opinion, reducing variability is equivalent to quality improvement. Later Shewhart worked for Bell Telephone Laboratories until his retirement in 1956. He wrote several articles and books, most representative being Economic Control of Quality of Manufactured Product in 1931, Statistical Method from the Viewpoint of Quality Control in 1939. On more thing about Shewhart: he is considered to be the grandfather of quality control.

Joseph M. Juran (Born in 1904)

Architect of Quality: The Autobiography of Joseph M. Juran (McGraw-Hill, 2003). "Juran begins his tale with his humble beginnings as a Romanian peasant and his families immigration to the United States. He recounts how he overcame poverty, anti-Semitism, bitterness and despair. This is a tale of how education wins over ignorance, persistence prevails over complacence and, more than anything else, how faith (in God, in family, in humanity and in the American dream) is rewarded."

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The pattern for Jurans life of hard work and dedication was set at an early age. “We grew up with no fear of long hours or hard work,” he writes. “We learned to seek out opportunities and to use ingenuity to gain from them. We accepted the responsibility for building our own safety nets. By enduring the heat of the fiery furnace, we acquired a work ethic that served us the rest of our lives.”

As a child, Juran endured the loss of his beloved mother, an indifferent father, bitter winters, the terror of anti-Semitism. Many residents of his native village in Romania perished in Nazi death camps – and grinding poverty. Consequently, he entered the working world bitter and socially inept, yet he was driven to succeed.

Jurans story parallels many of the great events of the 20th century. He landed his first job at Western Electric, which was the hot growth company of the 1920s. He weathered the Great Depression, he served his adopted country during World War II by working in the Lend-lease Administration, he helped Japan rebuild its devastated economy and he showed U.S. manufacturers how to compete successfully in the world market.

Also remarkable is the success of Jurans siblings. They, too, overcame their humble beginnings and led successful lives. For example, his brother, Rudy, became a successful bond trader; his brother, Nat, had a successful career in Hollywood, earning an Academy Award; his sister, Minerva, earned a doctorate degree and became a college professor – no small feat for a female Romanian immigrant.

Quality Digest issued an article which can be found at here. “No one in the last hundred years has had more influence on the worldwide practice of quality in business than Dr. Joseph Juran. In Architect of Quality, Juran recounts his fascinating life story, revealing how he overcame dire poverty and childhood tragedy to make a profound impact on business and society. Juran retraces his inspiring life journey – from an impoverished, tragic childhood in a tar-papered shack to his career as the revered man who helped invent and champion quality management systems, quality tools, and teams long before they became standard practice. Architect of Quality delves deep into Jurans motivations, sharing for the first time how the early hardships he faced and his relentless, aggressive spirit shaped his character and fueled his determination to succeed.”

Juran is considered to be after Deming the most important contributor to quality management. He became well know after his book publishing Quality Control Handbook in 1951. In Japan, Juran worked with manufacturers and taught classes on quality. Even his philosophy is very similar to Deming’s philosophy, there exists some differences: while Deming emphasized the need for organizational transformation, Juran believed that implementation of quality initiatives does not need dramatic changes. Juran is the author of definition for quality: fitness for use, rather than simply conformance to specifications. This way, Juran took into account the client, in terms of his needs. Quality trilogy “quality planning, quality control and quality improvement” represents another large contribution to quality. First part of trilogy is concerned with identification of customers, product requirements and override of business goals. The second part of trilogy implies the use of statistical control methods. As for the third part, Juran believe is that improvement should be continual, as well as breakthrough.

Armand V. Feigenbaum

Initiator of the concept of Total Quality Control, Feigenbaum published in 1961 one of his referencing book, named Total Quality Control. An interesting aspect regarding this book is that it was written when he was a doctoral student at MIT. The power of his ideas was discovered by Japanese in 1950s, about the same time Juran visited Japan. Quality principles set by Feigenbaum lay down on 40 keys. He promoted the concept of a working environment where quality developments cover entire organization; every single person in organization must have a truly commitment to improve the quality. Learning from other’s success story is essential.

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In his book Quality Control – Principles, Practices and Administration, Feigenbaum strove to move away from the then primary concern with technical methods of quality control, to quality control as a business method. Thus he emphasized the administrative viewpoint and considered human relations as a basic issue in quality control activities. Individual methods, such as statistics or preventive maintenance, are seen as only segments of a comprehensive quality control program.

Quality control itself is defined as: "An effective system for coordinating the quality maintenance and quality improvement efforts of the various groups in an organization so as to enable production at the most economical levels which allow for full customer satisfaction". He stresses that quality does not mean "best" but "best for the customer use and selling price". The word "control" in quality control represents a management tool with four steps: Setting quality standards, Appraising conformance to these standards, acting when standards are exceeded and Planning for improvements in the standards.

Quality control is seen as entering into all phases of the industrial production process, from customer specification and sale through design, engineering and assembly, and ending with shipment of product to a customer who is happy with it. Effective control over the factors affecting product quality is regarded as requiring controls at all important stages of the production process. These controls or jobs of quality control can be classified as:

1. New-design control,
2. Incoming material control,
3. Product control,
4. Special process studies.

Feigenbaum argues that statistical methods are used in an overall quality control program whenever and wherever they may be useful. However such methods are only part of the overall administrative quality control system, they are not the system itself. The statistical point of view, however, is seen as having a profound effect upon Modern Quality Control at the concept level. Particularly, there is the recognition that variation in product quality must be constantly studied within batches of product, on processing equipment and between different lots of the same article by monitoring and critical quality characteristics.

Modern Quality Control is seen by Feigenbaum as stimulating and building up operator responsibility and interest in quality. The need for quality-mindedness throughout all levels is emphasized, as is the need to "sell" the program to the entire plant organization and the need for the complete support of top management. Management must recognize that it is not a temporary quality cost-reduction activity. From the human relations point of view, the quality control organization is seen as both:

1. A channel for communication for product-quality information,
2. A means of participation in the overall plant quality program.

Finally, Feigenbaum argues that the program should be allowed to develop gradually within a given plant or company. Feigenbaums preface to the third edition of Total Quality Control in 1983 emphasizes the increased importance of buyer's perceptions of variation in quality between companies and also the variation in effectiveness between the quality programs of companies. Quality is seen as having become the single most important force leading to organizational success and company growth in national and international markets. Further, it is argued that: "Quality is in its essence a way of managing the organization" and that, like finance and marketing, quality has now become an essential element of modern management.

Against this background, Total Quality Control is seen as providing the structure and tools for managing quality so that there is a continuous emphasis throughout the organization on quality leadership:

1. Genuine investment in, and implementation of, modern technology for quality throughout sales,
2. Engineering and production: and top-to-bottom human commitment to quality and productivity.

As Feigenbaum says: "In effect, quality and its costs are managed and engineered and motivated throughout the organization with the same thoroughness and depth with which successful products and services are themselves managed and engineered and produced and sold and serviced". Such Total Quality Control programs are highly cost-effective because of their results in improved levels of customer satisfaction, reduced operating costs, reduced operating losses and field service costs, and improved utilization of resources. By-products such as sounder setting of time standards for labor may also be most valuable. Thus a Total Quality System is defined as: "The agreed company-wide and plantwide operating work structure, documented in effective, integrated technical and managerial procedures, for guiding the coordinated actions of the people, the machines and the information of the company and plant in the best and most practical ways to assure customer quality satisfaction and economical costs of quality." Operating quality costs are divided into:

1. Prevention costs including quality planning
2. Appraisal costs including inspection
3. Internal failure costs including scrap and rework
4. External failure costs including warranty costs, complaints, etc.

Reductions in operating quality costs result from setting up a total quality system for two reasons:

1. Lack of existing effective customer-orientated customer standards may mean current quality of products is not optimal given use,
2. Expenditure on prevention costs can lead to a several fold reduction in internal and external failure costs.

Kaoru Ishikawa (1915-1989)

Ishikawa was a Japanese consultant, father of the scientific analysis of causes of problems in industrial processes. One of his greatest contributions to quality was the diagram which has his name "Ishikawa diagram" or Fishbone Diagram.

Professor Ishikawa was born in 1915 and graduated in 1939 from the Engineering Department of Tokyo University having majored in applied chemistry. In 1947 he was made an Assistant Professor at the University. He obtained his Doctorate of Engineering and was promoted to Professor in 1960. He has been a7warded the Deming Prize and the Nihon Keizai Press Prize, the Industrial Standardization Prize for his writings on Quality Control, and the Grant Award in 1971 from the American Society for Quality Control for his education program on Quality Control.

While, perhaps ironically, the early origins of the now famous Quality Circles can be traced to the United States in the 1950s, Professor Ishikawa is best known as a pioneer of the Quality Circle movement in Japan in the early 1960s, which has now been re-exported to the West. In a speech to mark the 1000th quality circle convention in Japan in 1981, he described how his work

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took him in this direction. "I first considered how best to get grassroots workers to understand and practice Quality Control. The idea was to educate all people working at factories throughout the country but this was asking too much. Therefore I thought of educating factory foremen or on-the-spot leaders in the first place." In 1968, in his role as Chairman of the Editorial Committee of Genba-To-QC (Quality Control for the Foreman) magazine, Dr Ishikawa built upon quality control articles and exercises written by the editorial committee for the magazine, to produce a "non-sophisticated" quality analysis textbook for quality circle members. The book Guide to Quality Control was subsequently translated into English in 1971, the most recent (2nd) edition being published by the Asian Productivity Organization in 1986. Amongst other books, he subsequently published What is Total Quality Control? The Japanese way which was again translated into English (Prentice Hall, 1985).

As with the other Japanese quality gurus, such as Genichi Taguchi, Kaoru Ishikawa has paid particular attention to making technical statistical techniques used in quality attainment accessible to those in industry. At the simplest technical level, his work has emphasized good data collection and presentation, the use of Pareto Diagrams to prioritize quality improvements and Cause-and-Effect (or Ishikawa or Fishbone) Diagrams. Ishikawa sees the cause-and-effect diagram, like other tools, as a device to assist groups or quality circles in quality improvement. As such, he emphasizes open group communication as critical to the construction of the diagrams. Ishikawa diagrams are useful as systematic tools for finding, sorting out and documenting the causes of variation of quality in production and organizing mutual relationships between them. Other techniques Ishikawa has emphasized include control charts, scatter diagrams, Binomial probability paper and sampling inspection.

Turning to organizational, rather than technical contributions to quality, Ishikawa is associated with the Company-wide Quality Control movement that started in Japan in the years 1955-1960 following the visits of Deming and Juran. Under this, quality control in Japan is characterized by company-wide participation from top management to the lower-ranking employees. Further, all study statistical methods. As well as participation by the engineering, design, research and manufacturing departments, also sales, materials and clerical or management departments (such as planning, accounting, business and personnel) are involved. Quality control concepts and methods are used for problem solving in the production process, for incoming material control and new product design control, and also for analysis to help top management decide policy, to verify policy is being carried out and for solving problems in sales, personnel, labor management and in clerical departments. Quality Control Audits, internal as well as external, form part of this activity.

To quote Ishikawa: "The results of these company-wide Quality Control activities are remarkable, not only in ensuring the quality of industrial products but also in their great contribution to the company's overall business." Thus Ishikawa sees the Company-wide Quality Control movement as implying that quality does not only mean the quality of product, but also of after sales service, quality of management, the company itself and the human being. This has the effect that:

1. Product quality is improved and becomes uniform. Defects are reduced.
2. Reliability of goods is improved.
3. Cost is reduced.
4. Quantity of production is increased, and it becomes possible to make rational production schedules.
5. Wasteful work and rework are reduced.
6. Technique is established and improved.

7. Expenses for inspection and testing are reduced.
8. Contracts between vendor and vendee are rationalized.
9. The sales market is enlarged.
10. Better relationships are established between departments.
11. False data and reports are reduced.
12. Discussions are carried out more freely and democratically.
13. Meetings are operated more smoothly.
14. Repairs and installation of equipment and facilities are done more rationally.
15. Human relations are improved.

One major characteristic of Japanese Company-Wide Quality Control is the Quality Control Circle Movement started in 1962, with the first circle being registered with the Nippon Telegraph and Telephone Public Corporation. Starting in industry in Japan, these have now spread to banks and retailing, and been exported world-wide. Success in the West has not been as extensive as in Japan, however, although even there have been limitations too. The nature and role of quality circles varies between companies. In Japan a quality circle is a typically voluntary group of some 5-10 workers from the same workshop, who meet regularly and are led by a foreman, assistant foreman, work leader or one of the workers. The aims of the quality circle activities are:

1. To contribute to the improvement and development of the enterprise,
2. To respect human relations and build a happy workshop offering job satisfaction,
3. To deploy human capabilities fully and draw out infinite potential.

These aims are broader than is consistent with a narrow definition of quality as often used in the West, and Circle activities reflect this. The members of the circle have mastered statistical quality control and related methods and all utilize them to achieve significant results in quality improvement, cost reduction, productivity and safety. The seven tools of quality control are taught to all employees:

1. Pareto charts
2. Cause and effects diagrams
3. Stratification
4. Check sheets
5. Histograms
6. Scatter diagrams
7. Shewharts control charts and graphs.

All members of the circle are continuously engaged in self-and-mutual development, control and improvement whenever possible, the circles implement solutions themselves, otherwise they put strong pressure on management to introduce them. Since management is already committed to the circles, it is ready to listen or act. Circle members receive no direct financial reward for their improvements.

The Japanese experience of quality circles itself provides an insight into the problems of implementation in the West. Strangely enough, however, many companies in the West have attempted to minimize or even cover up the Japanese origins, apparently to avoid cultural

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rejection on antagonism to "Japanese workaholics" grounds. Even in Japan many quality circles have collapsed, usually because of managements lack of interest or excessive intervention. However, many have worked. There are now more than 10 million circle members there. The benefits are typically seen as being minor from any one improvement introduced by a quality circle, but that added together they represent substantial improvements to the company.

Perhaps more importantly, greater worker involvement and motivation is created through:

1. An atmosphere where employees are continuously looking to resolve problems,
2. Greater commercial awareness
3. A change of shopfloor attitude in aiming forever increasing goals.

Quality circles have been vigorously marketed in the West as a means of improving quality. There seems to be agreement, however, that they cannot be used naively, and take careful adoption for use in Western companies. Adoptions have been various and of varying effectiveness; in some companies circles have been successful, or regarded as such, in others they have failed. Many commentators, such as Philip Crosby, have warned against the fashion for quality circles as a cure-all for poor employee motivation or inadequate quality and productivity in either white-collar areas or on the shopfloor. The senior American Quality Guru Joseph Juran, in particular, has gone further, in throwing doubts on their likely effectiveness in the West at all where few company hierarchies are permitted with executives trained in quality management.

W. Edwards Deming (1900-1993)

Known as the father of quality, Deming was a statistics professor at New York University during the 40s. He studied for several years with Walter Shewhart; this was the base of his contribution to quality. After World War II, Deming was involved in assisting Japanese companies to reborn from their own ashes. His contribution was in improving quality, by setting a 14 points principles which should be the foundation for achieving quality improvements. Japanese companies applied extensively these principles; today's power of Japan and quality of their products has a strong root in this matter. Deming emphasized on the role of management in achieving quality. He noted that around 15% of poor quality was because of workers, and the rest of 85% was due to bad management, improper systems and processes. In his opinion, managers should involve employees in solving the problems, not simply to blame them for poor quality. Deming's 14 principles are:

1. Create constancy of purpose (short term reactions has to be replaced by long-term planning),
2. Adopt the new philosophy (management should adopt his philosophy, rather than to expect the employees to do that),
3. Cease dependence on inspection (it concerns to variation in other words, if there is no variation, no inspection is needed because all products shows no defects),
4. Move towards a single supplier for any one item (working with several suppliers, automatically involves variation in raw materials),
5. Improve constantly and forever (it refers to decreasing variation, as a key to better quality),
6. Institute training on the job (another source of variation is the lack of training of workers; train them properly to do a certain job, and they will do it with far less variation),
7. Institute leadership (distinction between leadership and supervising),
8. Drive out fear (eliminate fear at worker's level to get their support for improvements. Fear is counter productive),

9. Break down barriers between departments (here comes the concept of "internal customer" which is found in TQM; a department is a supplier for next one. The second one is the client for the first one),
10. Eliminate slogans (usually, it's not the employee who did it wrong, but it's the system who allowed that. No need to create tension on worker, as long as the system fails to prevent problems),
11. Eliminate management by objectives (as long as workers had to achieve an established production level, quality will be a secondary target),
12. Remove barriers to pride of workmanship (bringing problems all the time to worker's ears, will create a discomfort for them. Lower satisfaction of workers equals a lower interest for doing good items),
13. Institute education and self improvement (education is an asset. Everyone has to improve themselves),
14. Transformation is everyone's job (improvements exists at every level).

The most important book he wrote among other is Out of the Crisis in 1987. What is relevant to this book along these 14 principles is that he initiated the movement toward Total Quality Management, even he didn't used this expression? Nowadays, there exists Deming Prize, introduced by JUSE (Japanese Union of Scientists Engineers); this prize is awarded annually for best proponent of TQM.

Dr. Genichi Taguchi (Born in 1924)

Raised in textile town of Takamachi, Japan, Taguchi studied textile engineering.

WW II found him in Astronomical Department of navigation Institute. After several years in Ministry of Public health and Welfare of Japan, where he met Matosaburo Masuyama, a statistician who supported him, he was hired at Electrical Communication Laboratory, a rival of Bell Laboratories. Here, Taguchi worked to find ways of improving quality and reliability. Taguchi collaborated with Shewhart and Fisher.

Taguchi's contribution to quality consists in what is called Taguchi Loss Functions, also design of experiment to product design. His estimation was that 80% of all defective items are caused by poor design. Therefore, emphasis should be on design stage. Design of experiment is an engineering approach which is based on developing robust design; this is a design which results in a product which can perform over a wide range of conditions. In other words, it's easier to design a product which would operate under a large range of conditions, than to control these conditions so that the product to work as intended.

Loss function has implication to quality costs. Traditionally, if a product characteristic falls outside specification limits, it will increase the cost of poor quality. However, if that characteristic is closer to specifications and not to intended target, the quality of that product is poorer, even if it stills satisfy the requirements. This may lead to lower customer satisfaction. Taguchi proposed that as conformance values moves away from the target, loss increases as a quadratic function. This means that smaller differences from the target result in smaller costs.

6.16 Quality Circles

In manufacturing, the Japanese practice is that the responsibility for quality rests with the manufacturer of the part rather than "the quality deptt. acting as a staff function i.e. here the responsibility is of the production deptt itself". The workers are organised into teams (3 to 25 members per team) who themselves take the decision on solutions to quality problems.

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Even if one item produced is of Sub-standard & it is likely to effect the subsequent process, then the process shall be stopped immediately and the entire team will discuss the "cause and effect", decide the remedial action, rectify the process and then restart the production. This helps in bettering quality and reducing rejections, motivating workers as they feel proud of being a part of the decision process. This helps as an over-all achieving higher productivity, lowering wastivity & reducing cost of production per unit.

6.17 KAIZEN

'Kaizen' translated from Japanese means 'continuous improvement', taken from the word 'Kai' which means continuous and 'zen' which means improvement. It is a management philosophy and forms the basis of the Toyota Production System (TPS) as well as Lean Manufacturing.

The central philosophy of kaizen was probably best expressed by an earlier head of Toyota, Toyota Sakichi (1867-1930), who said that no process could ever be declared perfect and that therefore there was always room for improvement. Kaizen, as Toyoda Sakichi said, it is about continually aiming for improvement not just on the shop floor but across the whole company.

Example: TQM as developed at Toyota is an all-embracing concept, embracing the whole company. It reflects Toyota's belief that every worker in every department contributes to quality, no matter how indirectly.

Kaizen strategy is one of the most important concepts in Japanese management and is credited with being key to Japanese competitive success. Regarded as a conceptual "umbrella" consisting of a collection of Japanese practices Kaizen includes the following:

1. Customer Orientation
2. Total Quality Control
3. Robotics
4. QC Circles
5. Suggestion Systems
6. Automation
7. Discipline in the Workplace
8. Total Productive Maintenance
9. Kanban
10. Just-in-time
11. Zero defects
12. New Product Development
13. Small Group Activities
14. Productivity Improvement
15. Statistical Quality Control
16. Cooperative Labour/Management Relations

There are three superordinate principles which form the bedrock of the Kaizen philosophy. These principles are:

1. ***Process creates results:*** Without improving the process results do not improve. Look to the improvement of one or more of the five inputs to the process-persons, machines, methods, materials, and environment.

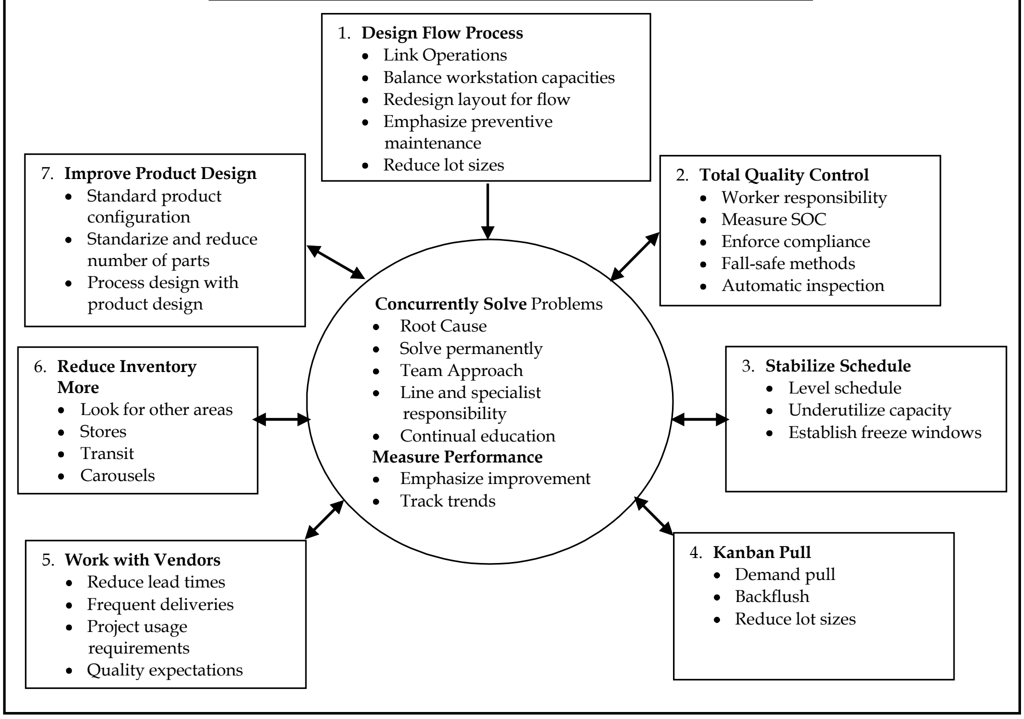
2. ***Total systems are more important than each of the parts:*** Look for optimum vs sub-optimum-a paisa saved in one department has no merit if it adds a rupee of cost in another department.

3. ***Be non-blaming and non-judgmental:*** Determine what is wrong not who is wrong. Find the cause of the problem and correct it but do not kill the messenger.

The Japanese make a distinction between Kaizen and innovation. Kaizen is gradual while innovation is viewed as being more radical. Radical changes to an organization's product line, business model or other operational area – dubbed kaikaku by the Japanese – provide the breakthrough in performance and growth while Kaizen can help the company to maintain its momentum and to perfect its new products, processes and business model.

Kaizen is a group activity and it employs small groups for initiating improvements usually in small increments over a longer period of time. A prerequisite to forming the team is to state some rules or guidelines for the operation and for the behaviour of the team. An ideal team consists of approximately four operators; a supervisor, a manager and two support personnel, thus bonding takes place over across traditional lines of authority. Typically an operator may emerge as the leader of the team although the plant manager may also be on the team. As the operators know the process better than anyone in the room they become the experts and direct the efforts of the supervisors, managers, and engineers. Team dynamics are quite interesting at times. The higher-level people on the team must be open to this type of power shift.

Figure 6.3: The Kaizen Concept



Source: This has been adapted from *'Operations Management for Competitive Advantage,* Chase, Jacobs and Aquilano, 10th Edition, Tata McGraw-Hill, New Delhi, 2003.

The management encourages suggestion or Kaizens from employees regarding possible improvements in their respective work areas. The success depends on the participation and response to the program. In different organizations there are different measures of the

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performance of the Kaizen program. The performance measures of the Kaizen Program of Maruti Udyog Ltd. are given below:

1. No. of ideas generated
2. No. of ideas implemented (e.g. 1400 last month = number of modifications in a product * number of units modified)
3. No. of suggestions given for communalizations of components across different models
4. No. of suggestions for communication of equipments across different lines
5. No. of suggestions for indigenization of spare parts via vendors.

In order to be successful change must take place rapidly. Kaizen is the process of implementing Lean tools in a much focused effort and a short amount of time, typically one to five days. The employees are rewarded for giving useful suggestions. These rewards are more of recognition, such as "Kaizen man of the Month" titles and certificates or small gifts, rather than monetary worth.

The Kaizen concept is shown schematically in Figure 6.3. Continuous improvement within the organization is achieved by closing the crucial loop from problem to corrective action by ensuring that all issues and corrective actions are resolved to a full resolution and by analyzing crucial data and trends.

One important aspect of Kaizen is its emphasis on process, complimented with management acknowledgement. Kaizen is oriented toward progressing in small steps. Given that any company is likely to find results in this approach, a manager can't usually go wrong by employing these techniques.

5's of Quality

5S is a method for organizing a workplace, especially a shared workplace. It's sometimes referred to as a housekeeping methodology, however this characterization can be misleading because organizing a workplace goes beyond housekeeping.

The key targets of 5S are workplace morale and efficiency. The assertion of 5S is, by assigning everything a location, time is not wasted by looking for things. Additionally, it is quickly obvious when something is missing from its designated location. 5S advocates believe the benefits of this methodology come from deciding what should be kept, where it should be kept, and how it should be stored. This decision making process should lead to a dialog which can build a clear understanding, between employees, of how work should be done. It also instills ownership of the process in each employee.

In addition to the above, another key distinction between 5S and "standardized cleanup" is Seiton. Seiton is often misunderstood, perhaps due to efforts to translate into an English word beginning with "S" (such as "sort" or "straighten"). The key concept here is to order items or activities in a manner to promote work flow. For example, tools should be kept at the point of use, workers should not have to repetitively bend to access materials, flow paths can be altered to improve efficiency, etc.

The 5S's are:

1. Seiri means Separating refers to the practice of going through all the tools, materials, etc., in the work area and keeping only essential items. Everything else is stored or discarded. This leads to fewer hazards and less clutter to interfere with productive work.

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2. Seiton means Sorting focuses on the need for an orderly workplace. "Orderly" in this sense means arranging the tools and equipment in an order that promotes work flow. Tools and equipment should be kept where they will be used, and the process should be ordered in a manner that eliminates extra motion.

3. Seis means Shine indicates the need to keep the workplace clean as well as neat. Cleaning in Japanese companies is a daily activity. At the end of each shift, the work area is cleaned up and everything is restored to its place. The key point is that maintaining cleanliness should be part of the daily work - not an occasional activity initiated when things get too messy.

4. Seiketsu means Standardizing; this refers to standardized work practices. It refers to more than standardized cleanliness (otherwise this would mean essentially the same as "systemized cleanliness"). This means operating in a consistent and standardized fashion. Everyone knows exactly what his or her responsibilities are.

5. Shitsuke means Sustaining, refers to maintaining standards. Once the previous 4S's have been established they become the new way to operate. Maintain the focus on this new way of operating, and do not allow a gradual decline back to the old ways of operating.

Case Study

Quality at Jet

The liberalization process of the airline industry in India started on December 11, 1990 with the issuance of the new Air Taxi Guidelines. Private airlines were designated as Air Taxi Operators (ATOs). The major ATOs to start operations with jet aircraft in 1992-93 were: East West Airlines, Damania Airways, ModiLuft, Jet Airways, Sahara India Airlines, and NEPC. Jet Airways took to the skies on May 5, 1993. The Air Corporations Act was repealed in January 1994, and by 1995, all the major private operators were granted Scheduled Airlines status. However, by 1996-97, four of the private airlines had to cease operations. The government-owned Indian Airlines, Alliance Air, Sahara and Jet remained the only players in the market.

"It was only with the entry of Jet Airways that the Indian passengers got a taste of the service they were entitled to as paying customers. Even as the other private carriers like ModiLuft, East West, Damania and NEPC have disappeared into the blue one-by-one, Jet Airways continues not just to survive but to fly even higher. It is practically the challenger to Indian Airlines' dominance over the Indian skies, with Air Sahara, the only other contender, being a distant third." (Business India, 1998)

Jet Airways achieved a market share of 6.6 per cent in its first year of operations (1993-94) and by 2000-01, achieved a market share of 40 per cent. Jet Airways today has a fleet strength of 28 Boeing 737-400 (Classics), Boeing 737-700/800, and five ATR 72-500 aircraft that operate over 215 flights daily to 39 destinations across India. The growth of Jet Airways has been accompanied by substantial investment in computerization, distribution (ticketing officers, GSA and interline agreements), infrastructure, and training.

From the time of its inception, Jet Airways endeavoured to deliver a world-class service, on the ground and in the air, by borrowing from the best practices of airlines and other service related fields in the world, and adapting them to Indian conditions. The Corporate Mission Statement of Jet Airways states that:

"It will be the most preferred domestic airline in India. It will be the first choice carrier for the traveling public and will set standards which its competitors will seek to match. This

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pre-eminent position will be achieved by offering a high quality of service and operations that are reliable, comfortable and efficient. Jet Airways being a world-class domestic airline, will simultaneously ensure consistent profitability; achieve healthy, one-term returns for the investors; and provide its employees with an environment conducive to excellence and growth."

An original business model of Jet Airways was developed to achieve the goals set in the mission statement. It addressed all individual elements required to create a successful airline. This included working in a synergistic and a cohesive manner to enable the airline to market a reliable, efficient and a comfortable travel experience to our customers.

1. Modern generation aircraft and young fleet to insure reliability, safety, efficiency and comfort.
2. Continuous upgradation and innovation of products and services.
3. Understanding the needs of the customer and managing the relationship.
4. Total coverage of India.
5. Maximize foreign currency earnings.
6. A well run and managed cost efficient operation.
7. Human resource development and training.

To become the 'airline of choice', Jet Airways has tried to deliver a consistently high level of service to its customers. Based on extensive research, Jet launched a campaign called 'Operation Revitalize'. The idea was to focus on areas where the gap with competition was narrow and to increase the gap even further in the other areas. This was supported by the belief that a truly world-class airline has to be good in not only one or two areas, but virtually in all areas in which the travel industry and consumers need to interact with an airline.

Jet claims to have set new service standards in India, and to have educated the Indian passenger on what service means. Keeping this in mind, Jet provides measures for the standard of service. They have standards in place for virtually every customer contact, varying from hard (quantifiable) to soft (intangible) standards. With customer service standards to guide their activities, they expect to be able to meet customer expectations.

Hard Standards can be measured in the following areas: appearance; customer-contact areas; lounges; reservations; sales; check-in; system reliability; baggage handling; punctuality; delay handling; aircraft cleaning; maintenance. Soft standards apply to all customer-contact areas; staff who are attentive and ready to help; polite staff; competence in dealing with any eventuality; level of tact displayed by staff in difficult situations; availability of airline staff; responsiveness to individual needs; being treated as an individual; an approachable staff; staff who are warm and friendly; being greeted with a smile and pleasant service.

Although soft standards are subjective and more difficult to monitor, Jet's management believes they are the standards by which many customers are likely to judge Jet's services. Hard standards have the potential to dissatisfy customers if they are not met. Soft standards, on the other hand, are powerful tools to impress the passengers with, to make them feel special, to recognize and treat them as individuals.

Standards do not only impact customer satisfaction, but also establish a common language. They also provide a sense of purpose and improve teamwork. These are some of the

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elements required to develop a strong service oriented culture. To close the gaps, Jet Airways uses the model developed by Prof. A. Parasuraman:

1. Gap 1: Management perceptions and customer expectations.
2. Gap 2: Management perceptions and service quality specifications.
3. Gap 3: Service specifications and service delivery.
4. Gap 4: Service delivery and external communications to customers.
5. Gap 5: Perceived and expected service.

Using this model, the management team is now in a position to look at the linkages as well as the overall impact. Many of the solutions were identified as being cross-functional and the respective teams have since based their action plans on this.

Jet Airways encouraged the spirit of innovation. Some innovative features that they offer are:

1. City check-in,
2. Through check-in,
3. Jet mobile,
4. Jet mall.

Their frequent flyer program has crossed the 100,000 mark and is presently close to the 200,000 mark, an affirmation that a large number of air travelers prefer to fly with them. The on-time performance of any airline is normally the yardstick by which the operational efficiency and reliability of the airline is measured. It is an area that Jet has placed great emphasis on. The on-time performance is continuously monitored. Every delay is analyzed and corrective action is taken to prevent reoccurrences.

Jet Airways feels an airline's most precious selling point is safety. It takes priority over every other concern. Safety is the bedrock on which any airline is built. They have, therefore, invested in one of the most modern fleets in the world. The average age of their aircraft is less than three years. The engineering and maintenance department has recently commenced with an ISO 9002 certification program, which they are confident they will get by next year.

Training

Although they have achieved major milestones in service, they still believe there is always room for improvement. No airline will continue to grow without due emphasis on training. They have therefore placed training under the guidance of a general manager, who has an excellent track record in airline operations in India and the Gulf. He and his team of dedicated trainers are responsible for corporate training program, especially management development, as well as line training.

The hard or physical product at Jet Airways has been developed to ensure efficiency and to provide the customer with tangible evidence of quality. The product in business class or Club Premiere reflects a sense of sophistication without being ostentatious. They pay much attention to the economy product and service, and strive to exceed the normal 'value for money' service that most airlines offer in economy class. Jan Carlzon, the man who turned Scandinavian Airlines' (SAS) $ 8 million loss into a gross profit of $ 71 million on sales of $ 2 billion in just two years, called every moment of customer contact a moment

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of truth. Jet Airways uses this philosophy to attain its standards of customer satisfaction. The customers are made to use the interactions with the airline staff to evaluate the performance of the airline. Jet Airways manages these 'moments of truth' to create 'golden moments' and not 'coffee stains', according to the CEO Steve Forte.

Questions

1. Analyse the case and efforts to manage quality at Jet.
2. Do SWOT analysis for Jet Airways?

6.18 Summary

- Quality Control implies working to a set standard of quality which is achievable and which has a ready market. Thus Quality Control means adherence to a standard or prevention of a change from the set standard.
- Quality control has the objective of coordinating the quality maintenance and improvement efforts of all groups in the organisation with a view to providing full consumer satisfaction. Statistical quality control enables these objectives to be attained most economically reducing scrap and rework, reducing machine downtime and minimising inspection.
- Objective decisions in quality management can be built only on facts. The decisions naturally would be as good or as bad as the data on which they are based. Thus, it is important to build that base of sound lines.
- When data are examined, it will normally be found that a few values will be extremely high or extremely low and most of the values tend to be concentrated within a region which is somewhere between the two extremes. This phenomenon is known as central tendency.
- The Process Capability may be defined as the capability of a process. This can be evaluated from the data which is free from assignable causes and hence the extent of variation exhibited by it is only under the influence of the chance causes alone.
- ISO stands for International Organisation for Standards. ISO: 9000 is a series of international standards for quality systems. It is a practical standard for quality applicable both to the manufacturing and service industry.
- Statistical Quality Control is the application of statistical techniques to determine how far the product confers to the standards of quality & precision and to what extent its quality deviates from the standard quality.
- Acceptance Sampling can be described as the post-mortem of the quality of the product that has already been produced. The term Acceptance Sampling 'relates to the acceptance of a consignment/batch of items on the basis of its quality.'
- TQM is a quality-focused customer-oriented integrative management method that emphasises continuing and cumulative gains in quality, productivity and cost reduction.
- Six sigma is a major part of the TQM programme. It is defined as 3 to 4 defects per million. It stresses that the goal of zero defects is achievable. The concept and method of six sigma is applicable to everyone and to all functions, i.e., manufacturing, engineering, marketing, personnel, etc.
- Kaizen is a group activity and it employs small groups for initiating improvements usually in small increments over a longer period of time.

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6.19 Keywords

Acceptance Sampling: The acceptance of a consignment of items on the basis of its quality.

Control Chart: A graphical representation between the order of sampling along x-axis and statistics along the y-axis.

Dispersion: The extent to which the data are scattered about the zone of central tendency.

Measure of Central Tendency: A parameter in a series of statistical data which reflects a central value of the same series.

Quality Circles: Voluntary groups engaged in managing quality.

Quality Function Deployment: represents a comprehensive analytic schema or framework for quality.

Quality Control: Working to a set standard of quality which is achievable and which has a ready market.

Statistical Quality Control: The application of statistical techniques to determine how far the product confers to the standards of quality and precision and to what extent its quality deviates from the standard quality.

Taguchi Methods: They provide a powerful means for isolating critical product design parameters that need to be controlled in the manufacturing process.

Total Quality Management: A quality focused customer oriented integrative management method that emphasizes continuing and cumulative gains in quality, productivity and cost reduction.

6.20 Self Assessment

State whether the following statements are true or false:

1. The objective of quality control is to make change acceptable to everyone.
2. The number of defective pieces and number of defects can be classified as attribute data.
3. The measures of central tendency are mean, median, mode and range.
4. Variance is square root of standard deviation.
5. The loss of a liquid substance through evaporation during heating is an assignable cause.
6. A wrong reading of electric current due to faulty meter is an assignable cause.
7. The probability of error in 100 per cent inspection is very low.
8. Statistical Quality Control can also lead to an improvement in product and process design.
9. Model 1 of ISO: 9000 limits itself to demonstration of supplies ability to test and inspect.
10. There is no great distinction between KAIZEN and innovation.

Fill in the blanks:

11. In a QC, a team comprises .... to .... members.
12. JIT realizes the benefits of ....
13. Six sigma stresses the goals of .... defects is achievable.

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14. Design standardization enables .... of the production process.
15. Quality .... be improved by investment in high technology alone.

6.21 Review Questions

1. What does your basic understanding say about quality control in life and in organisations?
2. Write short note on "Collection and Presentation of Data".
3. Explain the concept of "Central Tendency". What is its relevance?
4. What are chance and assignable causes of variations?
5. (a) What is the objective of inspection in a manufacturing industry? Write its uses at various stages and the errors associated with inspection.
   (b) Differentiate between hundred percent inspection and sampling inspection.
6. Discuss process capability and write procedure for its evaluation.
7. What do you mean by Control Charts in Process Control? Write the maintenance and usage of Control Chart.
8. What do you understand by 'Quality'? How the emphasis is shifting from Quality Assurance?
9. Define Statistical Quality Control. Describe briefly the techniques of SQC used in:
   (a) Inspection of Incoming Materials
   (b) Inspection during Process Control
10. Explain how the same is used for Inspection of Incoming Materials.
11. Explain the importance and Benefits of SQC techniques.
12. Explain the role of human behaviour in managing quality and also explain the following concepts:
    (a) Quality Circles
    (b) JIT Concept
13. Describe 'Use of Gauges and Fixtures' in Controlling Production Quality during Manufacturing.
14. "In order to be successful change must take place rapidly". Explain with reference to KAIZEN.
15. In a forging operation 20 samples were taken and number of defects observed in each sample. The results are as follows:

Sample	Number of defects observed
1	3
2	6
3	2
4	7

Contd...

Notes

5	3
6	6
7	14
8	2
9	7
10	13
11	2
12	2
13	8
14	3
15	9
16	3
17	6
18	1
19	2
20	8

Draw the UCL and LCL for the above mentioned data.

16. Draw the UCL and LCL for the data given in the table below:

Day of month	Number of purchase forms, n	Number of defective forms	Proportion defective, p
1	24	14	0.583
2	35	16	0.457
3	27	12	0.444
4	23	12	0.522
5	19	5	0.263
6	22	14	0.636
7	31	12	0.387
10	25	6	0.24
11	22	14	0.636
12	17	5	0.294
13	26	11	0.423
14	30	16	0.533
17	21	8	0.381
18	35	10	0.286
19	24	7	0.292
20	31	7	0.226
21	31	6	0.194
24	32	11	0.344
25	27	5	0.185
26	15	5	0.333
27	31	7	0.226
28	28	9	0.321

Notes

Answers: Self Assessment

1.	False	2.	False
3.	False	4.	True
5.	False	6.	True
7.	True	8.	True
9.	False	10.	False
11.	3, 25	12.	Quality Circles
13.	Zero	14.	Optimization
15.	cannot		

6.22 Further Readings

Books

Asaka, Tetsuichi and Kazuo Ozeki, *Handbook of Quality Tools: The Japanese Approach*, Cambridge, MA: Productivity Press, 1997.

Besterfield, Dale H., *Quality Control: Upper Saddle River*, NJ: Prentice Hall, 1997.

Burr, Adrian and Malcolm Owen, *Statistical Methods for Software Quality: Using Metrices to Control Process and Product Quality*, Cincinnati, OH: International Thomson Publishing, 1996.

Carlyle, W. Mathew, Douglas C. Montgomery, and George C. Runger, *Optimization Problems and Methods in Quality Control and Improvement*, Journal of Quality Technology 32, no. 1 (January 2000): 1-17.

Evans, James R, *The Management and Control of Quality*, Cincinnati, OH: South-Western College Publishing, 1999.

Juran, Joseph M., and A. Blanton Godfrey. eds. Juran's *Quality Handbook*, 5th ed. New York: McGraw-Hill, 1990.

Online links

www.iso.org/iso/management_standards.htm

www.iso14000-iso14001-environmental-management.com

www.sixsigmaspc.com/six-sigma/sixsigma.html

managementhelp.org/quality/tqm/tqm.htm

www.kaizen.com

Unit 7: Process Control Charts

Notes

CONTENTS

Objectives

After studying this unit, you will be able to:

- Know what a process is and how to analyze it
- Categorize processes
- Understand concept and measurement of performance
- Understand the importance and parameters relating to flexibility
- Know the importance and parameters relating to timeliness

Introduction

The design of manufacturing processes and service delivery systems cannot be made without considering product design decisions. Many aspects of product design can adversely affect operations performance. New products and services must be produced and delivered efficiently, at low cost, on time, and within quality standards. Process technology decisions relate to organizing the process flows, choosing an appropriate product–process mix, adapting the process to meet strategic objectives, and evaluating processes.

First, we need to understand how processes work and how they contribute to the competitiveness of the organization. What is a process? How can an organization choose the best process? How can an organization improve the already built process capacity? How can a process's weaknesses be determined? When to decide to change a process for the better? Answers to these questions are important. In this lesson, we will discuss concepts related to process design and planning.

Notes

7.1 Analyzing a Process

A process is any part of an organization that takes inputs and transforms them into outputs. The value the process generates is the difference between what the final product is worth to the customer and its initial value. The objective of the process is to provide the maximum overall value to the customer in the product.

Example: The Component Group of ECIL has product lines for electronic fuses, microwave components, Printed Circuit Boards that are used internally, ceramic components and nickel cadmium batteries. Through the use of labor, manufacturing technologies, assembly, energy, etc., raw materials and components are transformed to the end products of the company.

In the example above, though ECIL produces electronic fuses, microwave components, ceramic components and nickel cadmium batteries as end products for its customers, it also manufactures Printed Circuit Boards which form a part of other transformation processes within the organization. This exemplifies processes, which can be focused to meet customer requirements or can be a nested process for their own requirements.

A process can produce goods as in the case of ECIL, and it can also produce services. For instance, a telephone company provides a service when it connects you to communicate with another telephone user (who may or may not be a customer for the same telephone company) on your request. Providing equipment and technology that allows voices to be converted into a signal, then reconverting it at the other end, are also transformation processes. Similarly, banks provide services, and have processes that transform customer requests into products that provide value to the customer.

Let us start by looking at a process to understand how a process is analyzed. The example that follows is of a 'forging' process that many manufacturing companies use as a process to form components.

If you have ever seen a blacksmith beating on a piece of red-hot iron with a hammer, you have seen the simplest type of forging. Striking a piece of hot metal with a hammer is forging, and blacksmiths have been doing this for centuries. Forging's superior functional advantages of strength, fatigue resistance, reliability, and high quality combine into economic benefits for the company.

Forging is always an intermediate process. The components that are produced require finishing. The uniform dimensional relationships in forgings compared to other processes like metal casting etc., result in consistent machinability and predictable response to heat treatment. This, combined with obvious strength-to-weight ratios, make forgings a desirable process in many engineering industries. This process is generally used to form car wheels, gears, bushings, and other such parts.

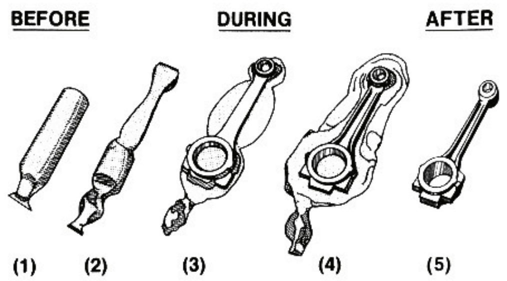
Manufacturers use many different techniques to forge metal. The most common is Drop forging—hammering hot metal into dies. Drop forging is a metal shaping process in which a heated work piece is formed by rapid closing of a die, forcing the work piece to conform to the shape of the die cavity. A die is a receptacle, made of high strength die steel that has the impression of the object that has to be forged. A hammer or ram, delivering intermittent blows to the section to be forged, applies pressure. The hammer is dropped from its maximum height, usually raised by steam or air pressure. Forging hammers apply force by the impact of a weight falling under the force of gravity.

Another process that is used is the Forging Press. Instead of forcing hot metal into a die with a hammer blow, it is pressed into the die with hydraulic pressure. A forging press consists of a hydraulic press, which exerts a force capable of pressing steel or a metal alloy into the shape of the forging die. Press Forging gives closer tolerances than hammer forging. It transmits a greater proportion of the work done to the work piece, compared to a drop hammer.

Telco had a Forge Division created to meet its need for forgings. In July of 1974, the Forge Division was planning to buy forging equipment to manufacture the 'connecting rod'. A 'connecting rod' is a component used in the engine of a TATA truck. It is the link between the piston and the crankshaft. In an engine the linear motion of the piston is converted into rotational motion by the crankshaft. The connecting rod functions as a lever connecting the engine to the crankshaft. It can rotate at both ends so that its angle can change as the piston moves and the crankshaft rotates. Figure 7.1 shows a forging of the 'connecting rod'.

Let us start by analyzing the processes. In 1974 the cost of a 2 tonne drop hammer was around ₹ 30.00 lacs. The price of a 2000 Tonne forging press, which is equivalent equipment for doing the same job, was ₹ 2.00 crores.

Figure 7.1: Metal Forging of a Connecting Rod



The study that was made by the engineering department considered two alternative processes for manufacture of the component.

Drop forging is a destructive process, using brute force—a large part of which is absorbed by the machine, dies and the foundation. Consequently, the life of the die in drop forging is around one third of that of a forging press. A drop forging die gives around 1500 components per sink compared to about 4500 in the case of the forging press.

A sink is a technical term used in die-making which indicates that a new impression is made on the die block. Normally, this does not involve a fresh die block.

1. Due to the large time required to remove the used dies and fit new dies, the setting time of a Drop Hammer was nearly four times that of a forging press. This reflected in lower equipment availability. The machine availability in case of a forging press was higher by nearly 25 per cent both because it was easier to change the dies and also because it required less frequent die changes.
2. This difference in the number of components produced per machine setting also involved higher cost in die-making in the case of drop forgings. There would be more consumption of die steel (for the making of dies) and also greater number of machine hours required in the die shop for the sinking of dies. This would impact the cost of each piece of forging manufactured.
3. The lower die life, all other parameters remaining constant, translated into higher levels of rejections. This is because when it was detected that the components were not being produced to specifications by the operator, the piece went to inspection and a decision had to be taken whether to rectify the die or change it. With shorter die lives, this process resulted in a higher number of rejects. As a percentage, in the case of drop forgings, it was nearly three times that of the press.
4. Due to longer set up times in drop forging, the furnace was not utilized to the same extent. Due to this, consumption of energy also was higher for a drop forging. This amounted to approximately 8 per cent per piece.

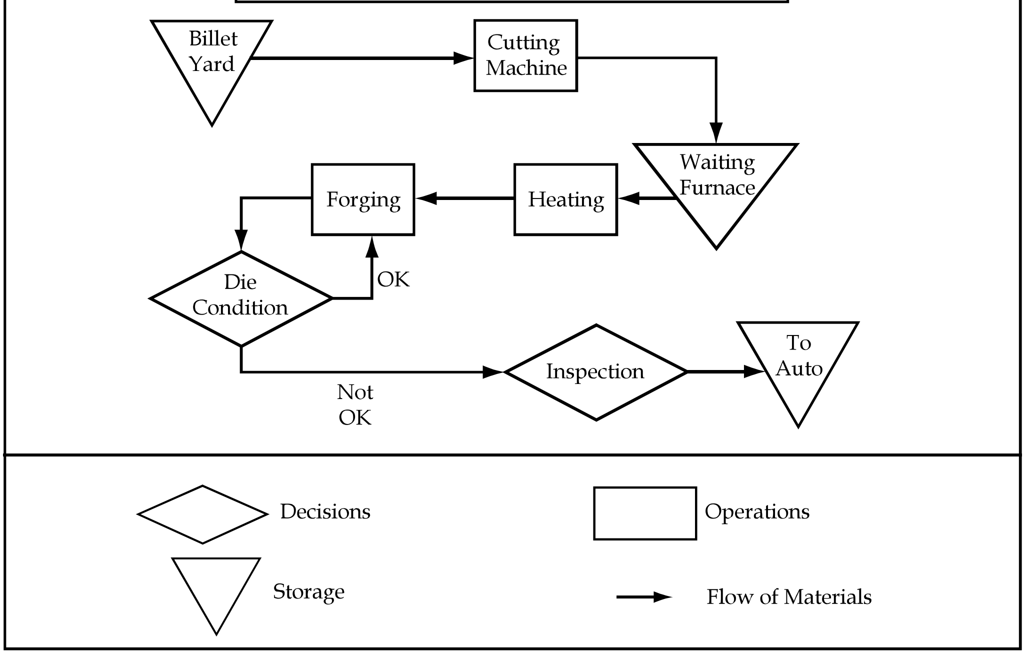
Notes

5. However, the production rate in the drop hammer was higher by 20 per cent compared to a forging press due to its lower **cycle time** of the drop hammer.

6. Both the Drop Hammer as well as the Forging Press could be used continuously 24 hours a day. As per international standards of International Labor Organization (ILO), the expected **machine utilization** would be around 65 per cent for either of the machines.

7. Also, as the drop forging machines were relatively simple and inexpensive, their **maintenance costs** were lower by nearly 30 per cent compared to a forging press, though drop forging equipment required more downtime for preventive maintenance.

Figure 7.2: Process Flow Diagram for Connecting Rod



The flow diagram for the process for forging of a 'connecting rod' is shown in Figure 7.2. Some of the basic elements of the process are: tasks, flows, decisions and storage. Tasks are shown as rectangles, flows as arrows, storage as inverted triangles, and decision points depicted as diamonds.

The flow diagram reflects the relationships between the different activities undertaken to complete the process. Many a time looking at a process one may be looking at a number of independent activities. One may need to evaluate other activities to arrive at a suitable decision. There is also the possibility that there is significant interaction between individual activities and processes that must be considered.

Very often, activities downstream impact the activities upstream or vice versa. Sometimes, activities can be taken up simultaneously so as to improve the speed and productivity of the process.

Standard word processing programs on a computer can be used to draw flow diagrams. Microsoft Office programs, i.e., Word, Excel and PowerPoint, have the provision of a drawing toolbar that helps in making flowcharts.

In the drawing toolbar choose the "Auto Shapes" button that has a number of options. One of them is 'Flow Chart'. On clicking this option, one will see all the standard symbols used in flowcharts and the required symbol can be selected and transferred onto the worksheet.

Notes

By clicking on the right mouse button, and by selecting 'Add Text' one can add texts in the desired box.

Going back to the 'connecting rod' problem, let us also examine the flow diagram. Low Alloy steel billets were stored in the billet yard. These came from GKW in Calcutta by trucks, each truck carrying 10 tonnes of billets.

As the weight of the cut piece for the 'connecting rod' was around 1.50 kg. both in the case of the drop forging and press forging, there was no impact on the forging process due to the incoming billets. However, the cost of inventory (work in process) was higher for the forging press, because a larger quantity was on the shop floor with value addition. There was a 5 per cent increase in cost.

On studying the process, it was found that:

1. There was nearly 20 per cent less machining required for components manufactured by press forging. This reflected a saving of around 17 per cent in cost of the component, but
2. If the cost of the forging were the criteria, it was more economical to manufacture it by 'drop forging'; and
3. If the cost of the machined component was the criteria, it was more economical to use 'press forging'. Machining costs were lower by 10 per cent.

The amount of metal that is required to be removed during machining is greater in drop forged components, as press forgings provide better tolerances. Management has to find a solution as to which process should be chosen and why.

How does one decide whether to use a drop hammer or a forging press for the manufacture of a 'connecting rod'? Higher production rate is desirable, and so are the lower capital costs and maintenance costs. The results of the analysis carried out by the Division showed that it was cheaper to manufacture the 'connecting rod' by drop forging compared to 'press forging'. There was a difference of 7 per cent in the cost.

7.2 Process Flow Charts

A Process Flow Chart is a tool that categorizes each activity and provides operation details to understand the process.

Generally, the operations are summarized in sequence so that the pattern of operations can be observed. If the sequence of activities varies from one job to the next, then that too provides useful information about the operations. The information is provided in a typical process flowchart, shown in Table 7.1. Note that more space is provided to give a detailed description of the nature of each operation in the last column.

Table 7.1: Sample Process Flow Chart

Process Flow Chart for:____________________ Page __of __

Overall Description of Process Charted: ____________________

Date Charted_______ .... Charted by: ________________

Check appropriate box: Current Process: ( ) .... Proposed Process: ( )

Distance Traveled	Time (avg.)	Symbol	Person Involved	Value Code	Description of Activity (indicate outcome)

Notes

7.3 Process Decisions

Process decisions are the building blocks that are used to design the operational requirements of the organization. One of the most important decisions of Operations Management is to choose a well-designed, well-functioning process that meets the objectives of the organization. The process related decisions that the organization has to take include the following:

1. ***Make or Buy:*** What parts of the product should be made in-house and what should be outsourced?
2. ***Flexibility:*** What are the requirements of the organization to handle products and processes, their variety and complexity?
3. ***Level of Mechanization:*** How to balance the mix of people skills and automation?
4. ***Process Choice:*** What processes should the organization employ, and why?

One can start by exploring the make or buy decision. Once it is decided what we are going to make, it is easier to take a decision on the process or processes that will be employed.

7.3.1 Buy or Make Decisions

Processes underlie all activities and hence are found in all organizations and functions. In addition, processes create an inter-connected set of linkages, which connect the external and internal linkages. These linkages are critical because it is not possible for an organization to manufacture or process all its requirements internally. For instance, an automobile manufacturer would seldom consider manufacturing steel although it forms the largest single item used in his product. Nor would an automobile manufacturer manufacture headlights or dashboard instruments.

There are different categories of components, sub-assemblies and other inputs that go into an organization's products. These categorizes are as follows:

1. ***Proprietary items:*** Proprietary items are based on the design of the supplier and used in the end product without change in its basic form or characteristics, for example, headlights, and dashboard instruments.
2. ***Standard components:*** These components are universally designed for general use. For example, standard or customized fasteners are used in most manufactured products.
3. ***Specialty components:*** These components are specialized in nature like the types which though used in all vehicles are a speciality product supplied by manufacturers of rubber products.
4. ***Commodity type items:*** These items are supplied either to standard specifications, or customized to the requirements of the user by the supplier. In the case of an automobile manufacturer, steel would constitute such an item. In the case of a steel manufacturer, coking coal, iron ore, limestone, dolomite, etc. would fall in this category.

These items involve large investments and are generally classified as different industries. An investment in such bulk commodities or products, as a vertical integration strategy, is not very common.

The remaining components, sub-assemblies, etc., are those designed for the product. These can be related to what the management considers as:

1. Core, and
2. Non-core activities.

The designation is relative. Core and non-core activities can change depending on the perception of management. For example, when TELCO put up its Jamshedpur plant, it decided to have its own foundry and forge divisions. These were considered core activities that would reflect upon the quality of the TATA vehicle.

However, when TELCO expanded its operations to Pune, the management decided that the investment in a forge plant was not warranted, but a foundry was. Gradually, as the capacity of TELCO increased, the management realized that it would be better off by investing in expansion of its automobile assembly capacity and engine manufacture rather than in forgings or castings. Today, most of the forgings and casting required by TELCO are outsourced.

How many activities—related to the product—that the organization performs depend on its Operations Management strategy and the investments required for backward or forward integration. Not all the components need necessarily be produced or activities be performed by the organization. The manufacture of automobiles, once the most vertically integrated of all businesses, is now among the most disaggregated.

Companies are focusing on the functions they can best perform, and outsource the rest to their partners. Designated non-core activities or secondary activities are often outsourced to a specialist to realize not only higher performance levels but also significant savings.

The Operations Management manager must assess the current performance of a process or asset and also it's potential for improvement so as to take a correct decision regarding outsourcing. He must judge whether suppliers are meeting standards and are abreast with changes in the field. When managed well, assets will follow the operators—inside or outside an organization—that can create the most value.

By shedding assets, some organizations boost their return on invested capital in the short term. They take on the roles as product designers, solutions providers, industry innovators, or supply chain integrators. But in handing over capital-intensive manufacturing assets to outside suppliers, companies may be losing the very skills and processes that have distinguished them in the marketplace.

Organizations need to critically assess the pros and cons of limiting its manufacturing investments, and ensure the decision implemented improves its company's performance by maximizing the products value.

For example, Nokia has been working towards improving the productivity of its existing assets and integrating its sourcing, sales, and manufacturing efforts. The company has designed its new Beijing complex, for example, to assemble phones with zero inventories for the supply base that it manages. All components come from their suppliers.

The basis for decisions on outsourcing or vertical integration is knowledge of the true cost of manufacturing goods internally against the cost of acquiring these goods from suppliers. A good decision is based on the assessment by the senior management in the light of the following three dimensions of performance:

1. ***Strategic:*** Does owning or enjoying preferential access to the asset have any strategic importance? How does the company's manufacturing strategy meet the needs of its overall business strategy? For example, TELCO took a decision on building a forge division at Jamshedpur, when the forging industry in the country was not developed. It gave TELCO the advantage that it was certain of the quality of the TATA vehicle, especially as the steering components were forgings.

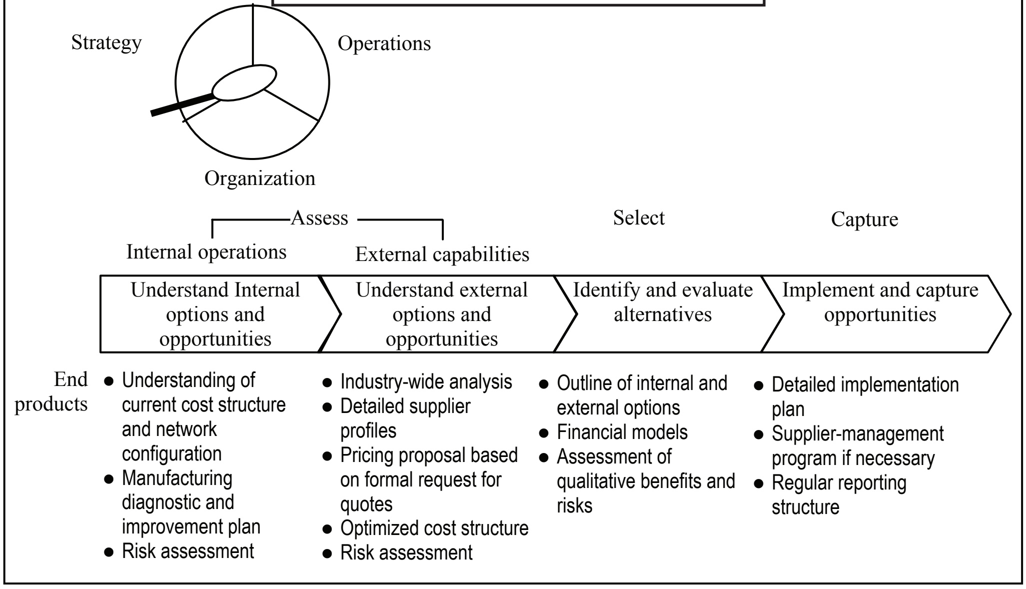
2. ***Operational:*** What are the performance targets and needs of the manufacturing process and the supply chain? What are the optimal supply chain arrangements for meeting those targets? In the case of the TELCO, the closest forging units were Wyman Gordon and Bharat Forge. Both were on the west coast, while Jamshedpur was located on the east coast. Neither of these companies was in a position to come forward in delivering in a crisis.

Notes

3. ***Organizational:*** Does the linking of manufacturing strategy to business strategy, achieve results that meet the objectives? Vertical integration is generally attractive when input volumes are high. High volumes permit task specialization and greater efficiency. Established companies, whether they manage reconfigured networks or operate long-standing internal ones, seldom have the skills to transform their supply chains.

Senior managers must use this three-dimensional perspective to assess, first, internal operations; then, external capabilities; and, finally, what combination of the two can create the most value and capture it through managing the network effectively. The schematic representation of the steps and actions involved are depicted in Figure 7.3.

Figure 7.3: Framework for Outsourcing Decisions



A new concept of virtual factory is now finding acceptance. Manufacturing activities are carried out in multiple locations by suppliers and partner firms form a part of a strategic alliance or a larger "supply chain." The role of manufacturing in one central plant is eliminated. The virtual factory may have no manufacturing organization, but manages the integration of all steps in the process—no matter where physical production actually takes place. The implications for process planning are profound: This will change the role of Operations Management from monitoring activities in manufacturing to a deep understanding of the manufacturing capabilities of the production network and task coordination.

7.3.2 Level of Mechanization

The level of mechanization determines the capital intensity of the process. The mix of equipment and human skills in the process defines capital intensity.

With an increase in the level of mechanization, the relative cost of equipment and the capital intensity also increases. There is a payoff between the capabilities of technology and investment represented by levels of mechanization, and investment and productivity. Adding technology can significantly improve quality and decrease product costs in many processes.

For designing a new process, improvement of an existing process or redesigning of an existing process, the capital intensity needs to be determined. There is a range of choices, from operations utilizing very little automation to those requiring task-specific equipment and very little human intervention.

Generally, capital-intensive operations must have high utilization to be justifiable. Also, automation does not always align with a company's competitive priorities. If a firm offers a unique product or high-quality service, competitive priorities may indicate the need for skilled servers, hand labor, and individual attention rather than new technology. Thus, the automation decision requires careful examination.

One big disadvantage of capital intensity can be the prohibitive investment cost for low-volume operations. Processes that use general-purpose equipment that are not capital-intensive have small fixed costs, although the variable cost per unit produced is high. Only high volumes can justify continuous processes at producing the product with variable costs so low that the price of the product turns out to be low enough so that consumers can afford to buy it.

The top of the pyramid in mechanization is automation. Automation is a system, process, or price of equipment that is self-acting and self-regulating. Although automation is often thought to be necessary to gain competitive advantage, it has both advantages and disadvantages. Manufacturers use two types of automation systems:

1. Fixed, and
2. Flexible.

1. ***Fixed Automation:*** Fixed automation is particularly appropriate for line and continuous process choices. It produces one type of a part or product in a fixed sequence of simple operations. Until the mid-1980s, most US automobile plants were dominated by fixed automation. Chemical processing plants and oil refineries also utilize this type of automation.

   Operations managers favor fixed automation when demand volumes are high, product designs are stable, and product lifecycles are long. These conditions compensate for the process's two primary drawbacks: large initial investment cost and relative inflexibility. The investment cost is particularly high when a single, complex machine (called a transfer machine) is capable of handling many operations. Since fixed automation is designed around a particular product, changing equipment to accommodate new products is difficult and costly. However, fixed automation maximizes efficiency and yields the lowest variable cost per unit if volumes are high.

2. ***Flexible Automation:*** Flexible automation is production equipment that can be changed easily to handle various processes. These equipments are programmable. This characteristic is useful for both low-customization and high-customization processes. Manufacturers of FMCG products use high volume production lines, with low customization but high variety. In the case of high customization, the equipment makes a variety of products in small batches that can be programmed to alternate between products.

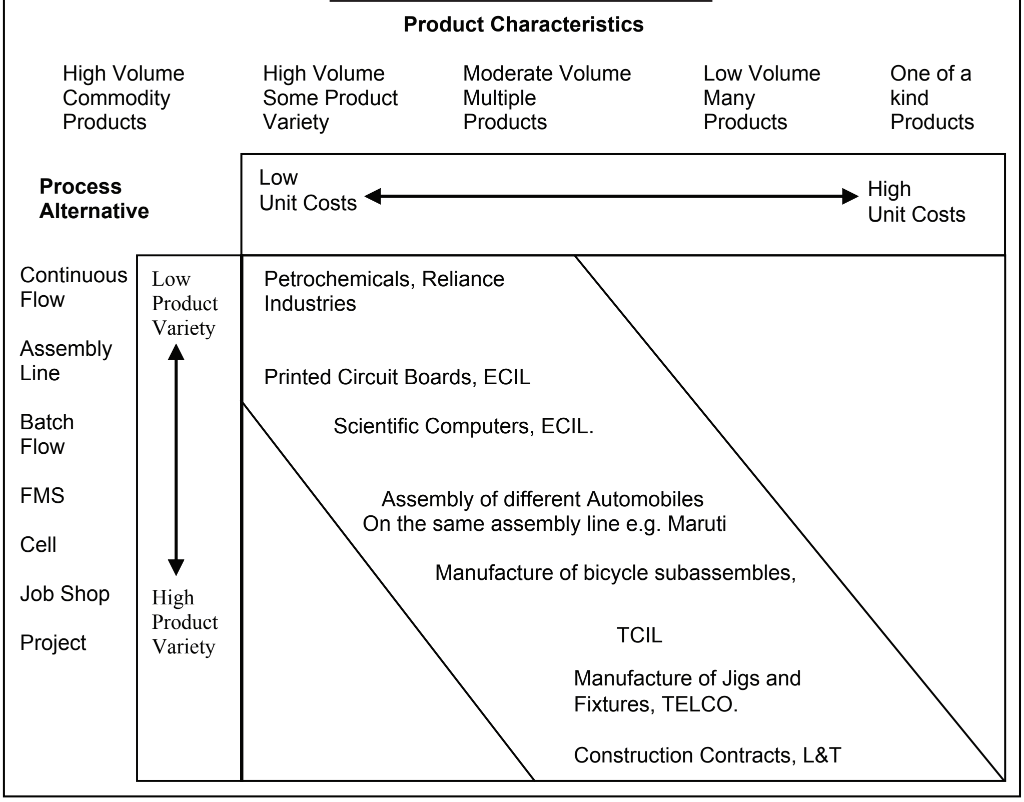
These equipment types have the ability to accept reprogramming. When the equipment that has been dedicated to a particular product is at the end of its lifecycle, the machine can simply be reprogrammed with a new sequence of operations for a new product.

7.3.3 Process Choice

The relationship between production system and product characteristics is depicted on a product-process matrix and forms the basis for selection of the production process. In this matrix, product characteristics are defined on three dimensions, the volume, unit cost and the nature of the product. Processes are defined on the basis of the production system. As the volume increases and the product narrows, specialized equipment and standardized material flows become economically feasible.

Notes

Figure 7.4: Product-Process Matrix



The production system also has to deal with low volume, multiple standard products or high volume multiple standard products. Operations Management has to combine these patterns in different manners. In many production systems, parts manufacture is a process focused system and assembly is a product focused system.

Figure 7.6 shows these relationships with examples. The vertical axis within the matrix reflects the links between process choice and product variety, and the horizontal axis process choice, represent the subsequent link between process choice and the other product characteristics e.g., volume, nature and unit costs. The diagonals help place a firm with the most appropriate match up of process.

For example, a firm that produces low volumes of unique products is advised to use a job shop structure, whereas one that produces high volumes of commodity products should best use a continuous flow process. The industries listed within the matrix are presented as representative types in their structural niche, though it is possible for them to choose another position on the matrix.

If an organization decides to use a job shop process for a high-volume standard product, the firm would normally lose significant opportunities to increase market share or make more profit. Lacking process efficiency, such a firm may become incapable of competing with firms that have more efficient processes. Similarly, if a firm sets up a line process for low-volume customized products, it would incur significantly higher investments in processes, equipment, and methods than necessary.

Based on the product-process matrix there are two ends of a continuum of production systems, which are: (a) process focused systems, and (b) product focused systems.

Notes

1. ***Process Focused Systems:*** A production system for many product categories must be flexible to process or transform the product in accordance with the client specifications or requirements. Such production systems are based on the nature of the processes. These are intermittent processes where each component flows from one process to another. Machines and production facilities are arranged in groups which process different components as required.

   For example, ECIL manufactures computers for scientific applications. These are mostly purchased by scientific research and educational institutions. Each computer has to be custom built to the end-user's requirement. ECIL has to develop software suited for the applications of their customers. In such products, the processes must be capable of meeting the individual component specifications and assembling them in their special configurations to meet the customer specifications.

   Another example is a die shop for a forging unit. There a section comprising of 'cutting machines', another section for 'shaping machines', yet another section for 'milling machines', 'grinding machines', boring machines', etc., and finally a section for 'die sinking machines'.

   The 'die block' is first taken to a 'planning machine' to make the surfaces parallel so that reference points can be established. Then the 'shaping machines' help form the jointing of the die, till it finally reaches either the spark erosion machines or the die sinking sections for the form to be sunk into it. After the form is complete, the die moves to the finishing section, where the die surfaces are polished and ground and undergo final inspection.

   Such production systems are planning intensive. The utilization of the machines in the different sections is dependent on the quality of planning.

2. ***Product Focused Systems:*** Many products are mass produced. These are high volume standardized products. These systems approach continuous flow in the use of the facilities. In the case of such systems, special processing equipment and entire dedicated production systems are desirable. Processing is adapted completely to the product. Individual processes are mechanized, automated and physically arranged in the sequence required in the processing of the product and the entire system forms an integrated production system, like one giant machine.

For example, ECIL also manufactures black and white television sets, colored television sets and transistorized village TV receiving sets with front end converters and antennae. The other components that ECIL manufactured for the electronics industry which included passive components like resistors, potentiometers and capacitors (now mainly tantalum), active components like semi-conductor devices and special diodes, thick film devices (hybrid micro-circuits), and Printed Circuit Boards (PCBs), etc., are also sensitive to the scale of production.

These types of systems have a product focus and a production objective of standardization and low cost. To sustain these systems requires a continuous flow of raw materials and components. Quality and inventory control are critical parameters in these systems.

Task How would you go about designing a process for a new product? What would you need to do to ensure that the product provided maximum value to the customer?

Notes

7.4 Characteristics of Different Production Systems

The product-process matrix allows a firm to assess the 'strategic fit' between its current posture and current resources. It provides the basis for managers to choose from the alternative processes. This decision should be based on the following criteria:

1. What will each alternative cost in the short-term and long-term?
2. What will each alternative provide in terms of cost, quality, time, and availability of output?
3. What will each alternative require in terms of raw materials, energy, infrastructure, managerial talents, and other inputs?

The product-process matrix can also indicate how to shape operations strategy in the future. Consider a firm that has to design a future process for a product whose demand is going to increase substantially. The firm should plan to redeploy its future resources toward more high-volume and low-cost processes—assembly lines, systematic automation of processes, greater process engineering expertise, more standard operating procedures, dedicated equipment, greater specialization, and the like.

Similarly an organization, foreseeing the growth of the Internet and/or flexible resources, must change its strategic alignment from cost toward greater product variety and greater flexibility.

The characteristics of different production systems as obtained from the product-process matrix are summarized in Table 7.2.

Table 7.2: Characteristics of Different Manufacturing Systems

Characteristics							
Process	**Volume**	**Product Variety**	**Product Flow**	**Facility Layout**	**Fixed Costs**	**Variable Costs**	**Equipment**
Contiguous	High	Dominant	Standard	Product	High	Low	Special Purpose
Assembly line		Standard With minor Modification	Dominant	Product	High	Low	Special purpose
Batch		Some variation	Dominant	Product	High	Low	Some Flexibility
Flexible Manufacturing Systems		Moderate Variety	Dominant	Product	High	Low	Flexible
Manufacturing Cell		Moderate variety	Dominant	Product	Moderate	Low to moderate	Flexible
Job shop	Low	Major Differences	Random	Process	Low	High	Flexible
Project	One	One-of- a-kind	Not applicable	Fixed position	Low to moderate	High	Flexible

Table 7.2 also shows the relationship between process choice and the other key process decisions and how they are tied to volume. The relationship of the process with volume is often considered the common denominator in determining process design strategy. This, in turn, comes from

the product strategy. Process selection, therefore, forms a useful link between marketing and manufacturing strategies.

High volumes at a process typically mean all of the following:

1. A Line or Continuous Process.
2. ***More Make than Buy decisions:*** High volume creates more opportunities for vertical integration.
3. ***Less Resource Flexibility:*** When volumes are high, there is less need for flexibility to utilize resources effectively, and specialization can lead to more efficient processes.
4. ***Less Customer Involvement:*** At high volumes, products are generally standardized which do not require customization.
5. ***More Mechanization:*** High volumes justify the large fixed costs of an efficient operation.

Low volume typically means the following:

1. A Project or Job Process.
2. ***Less Vertical Integration:*** Low volumes eliminate most opportunities for backward or forward vertical integration.
3. ***More Resource Flexibility:*** When volumes are low, workers are trained to handle all types of customers and often dispose of customer requests.
4. ***More Customer Involvement:*** There is more customer involvement because processes have to be aligned to customization.
5. ***More Labor Intensive:*** The production flexibility is obtained through limited mechanization and more labor-intensive processes that require little investment.

Of course, these are general tendencies rather than rigid prescriptions. Exceptions can be found, but these relationships provide a way of understanding how process decisions can be linked coherently.

Because of this evolution in the production structure, the process is frequently related to the product lifecycle. In the early stages of the product lifecycle, the production system must deal with low volume and during the maturity stage deal with high volumes. These characteristics are also important to design processes, which have been discussed later in this unit.

7.5 Services Processes

Processes in services are similar to those used in production. Process sheets and flow diagrams are used to specify a process. Typology of processes is also similar. However, a majority of service operations operate on a MTO or ATO basis, in part because it is not possible to inventory the product being requested. For example, restaurants stock ingredients in anticipation of a customer's arrival but await a request before they process it. Whether the meal is ETO or MTO will also depend on the degree of meal customization the restaurant practices.

Lead times become a very important consideration in many service operations. Some competitive situations allow a delay, which is called a backlog. When orders are placed, they may have to wait in a queue until the firm has the resources to start making the product. When business is good, backlogs may be extended—when things start to slow down, the backlog shrinks.

Firms are able to do this, in part, because customers want a particular product and are willing to wait. Earlier customers wanting a Bajaj Scooter had to and were willing to wait. Yearlong backlogs were common then. However, companies backlogging orders put it at a risk of losing a customer as the uniqueness of the product fades.

Notes

Generally, lead-time reductions enhance value. This is especially true when the organization can be counted on to perform as promised. Hence managers strive to reduce both the duration and the variability of lead-times.

Whether the customer, the seller, or the maker of the product bears the burden of lead-time depends on the market orientation a firm uses to supply a product. The ability to deliver a product faster than the competitors can give a firm a competitive advantage.

In manufactured goods, there is a relationship between volume and process decisions for service operations. The key differences between typical manufacturing and service operations are customer contact and capital intensity.

Many low contact systems, such as cheque processing at a bank, can be treated as quasi-manufacturing systems, since most of the principles and concepts used in manufacturing apply to these. Figure 7.5 shows this relationship and relates it to the capital intensity and automation in the process.

Figure 7.5: Service Processes

	Low Customer Contact	High Customer Contact
Capital Intensive	**Quasi Manufacturing** Postal Services Cheque Processing	**Custom Service** Beauticians Air Express Services
Labor Intensive	**Mass Services** Cinema Halls Restaurants	**Professional Service** Medical Diagnosis Legal Serviceds
	Rigid Process Technology	**Flexible Process Technology**

Let us look at an example in greater detail. Postal services operations start with the collection process. They employ postmen who pick up documents from the different letter-boxes. Some customers give their packages at the counter of the post offices.

The particulars are entered in the computer at the collection centers. The consignments are then sorted, put in separate bags with coded prefixed labels and sent to railway stations or airports at the gateways where they are further sorted in accordance to their destinations.

Based on the codes the consignment reaches its destination, where it is sorted again on the basis of the post office it falls under.

Postmen are then assigned delivery of the letters or documents.

This is a high volume, repetitive operation, with limited customer contact and therefore is becoming more and more capital intensive as modernization of post offices continues to take place in the country.

Processes must be designed around the service strategies selected for them. Thus, the manager must give particular attention to these strategies when designing a service process.

High volumes at a service process typically mean the followi ng:

1. ***Process:*** The product or the customer moves through a series of standardized steps, such as in line flows or assembly lines. The basic service and service specifications are standardized and tightly controlled. Such services increase volumes and process replicability. An

example is grocery shopping at Morning Stores. The customer moves from one row to the next, making product selections and then paying at the end of the line.

2. ***In-house Production:*** High volumes make it more likely that the service provider will minimize the processes that are outsourced.
3. ***Resource Flexibility:*** High process volumes and repetition create, less need skill levels that are not high. Resources can be dedicated to each standardized service, and jobs are more specialized.
4. ***Customer Involvement:*** The customer may be involved in performing self-service activities or in selecting from standard service options rather than getting customized treatment. Often, the customer is not present when the process is performed, as in the post office described earlier. The little contact that occurs between employees and customers is for standardized services.
5. ***Automation:*** High process volumes and the repetitive nature of the tasks allow more automation. This may require high capital intensity. Where the customer is not involved with the process, automation possibilities increase.

Low volumes typically mean the following:

1. ***Process:*** Such services require to be defined for each new project or job. These can change considerably from one to the next. Customized treatment means a low-volumes process, and each customer requires different changes in the process itself. Examples are processes for physicians and restaurants. A good service operation understands unique individual needs and accounts for it in the process.
2. ***Outsourcing:*** Low volumes make it more likely that the service provider will outsource processes that can be executed better and cheaper outside.
3. ***Resource Flexibility:*** Employees must have high-skill levels and equipment should be able to handle new or unique services on demand. There is an increased requirement for versatility and flexibility to handle a wide array of customer requests.
4. ***Customer Involvement:*** Low volume is typical of high customer contact. Employees interact frequently with customers, to understand each customer's needs. They must also be able to relate well to their customers. Service quality is assessed not merely on technical skills but also on judgments the service personnel provide.
5. ***Capital Intensity:*** Custom is often very labor-intensive. The major problem with Indian software companies is the high turnover of highly skilled workers. Equipment may require little investment but more investment is in retaining skills.

These are general observations and there will be many exceptions. However, these relationships provide a way of understanding how process decisions can be linked coherently.

7.6 Designing Processes

At the product conception stage, manufacturing proposes and investigates processes and concepts. When the product concept has been finalized, the role of process management then is to develop cost estimates, define process architecture, conduct process simulation and validate suppliers.

Concurrently with the detailed product design, process management is involved in the designing of the process, designing and developing tooling and participating in building full-scale prototypes.

Notes

At the time the product development teams are developing the prototypes, the process management teams test and try out tooling and equipment; help build second-phase prototypes; install equipment and specify process procedures.

This is followed by building pilot units in commercial process; refining process based on pilot experience, training personnel and verifying supply channels.

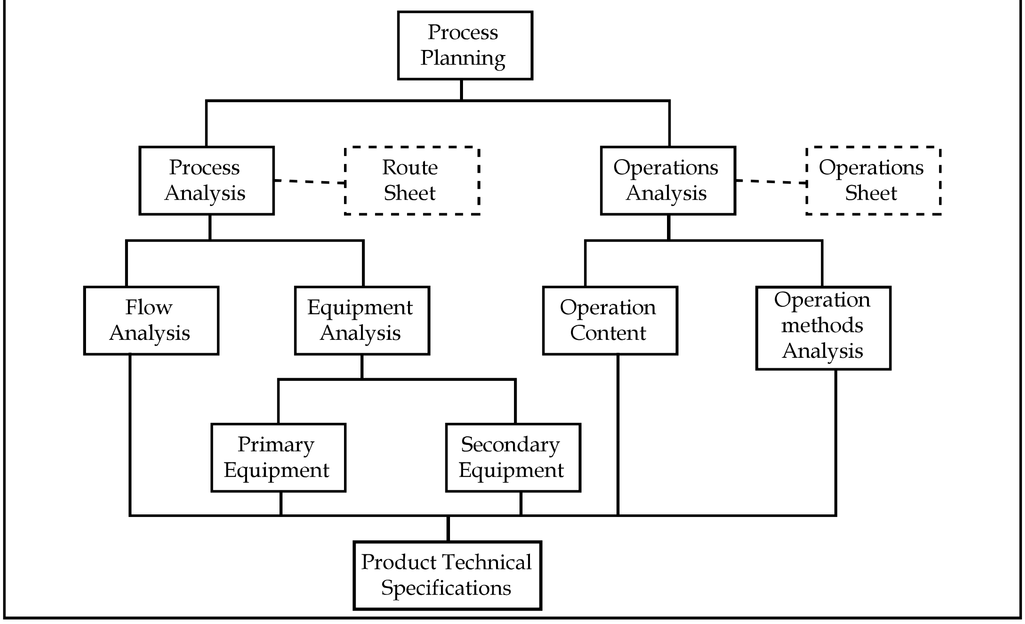
Finally, at the release of the product, process management has to ramp up plan to volume targets, meet targets for quality, yield and cost.

The analytical work of process planning can be divided into two classes;

1. Process analysis, and
2. Operation analysis.

This nomenclature is not mutually exclusive; one influences the other, as can be seen in Figure 7.6.

Figure 7.6: Functional Model of Process Planning



1. ***Process Analysis:*** is governed by the main process decisions we have described earlier, namely: capital/labor intensity, outsourcing, resource flexibility and volumes. These four decision areas represent broad, strategic issues that have to be decided prior to finalizing the process design. It is concerned with the overall set of operations constituting the process.

   Process Analysis is not directly concerned with the content of the operations constituting the process, or with the detailed method of carrying out the operations. It comes out with recommendations for primary (work stations) and secondary equipment (accessories) required for the most effective and efficient production of the product and the workflow. For example, an administrative department may be looking at the flow of information through and from the department.

   The process analysis decisions are reflected in a route sheet. A route sheet normally specifies the sequence of operations in a process by a name and number. The name, number, and geographical location of each workstation are required for each operation, and the special purpose accessories for each operation are identified by name and number. A route sheet is prepared for each component and for the end product itself. If a product has ten components, there will be eleven route sheets for the product.

2. ***Operation Analysis:*** Once the process analysis decisions have been taken, process management has to determine exactly how each process will be performed. This is called 'operations analysis'.

   Operations Analysis is concerned with the work content constituting the operation and the method of performing this work, given the resources allocated to the process. For example, in a manufactured product material is being processed in some form. Each operation should achieve a certain portion of the product technical specifications. Successive operations in the process should finally result in the output having achieved the technical specifications.

   Each operation will have certain work content. The wok content is broken down into 'steps'. For example in a grinding operation, the first step is securing the material to the holding device. The second step is to start the machine. The third step is for the operator to observe if the grinding machine performs the operation correctly. The fourth step is for the operator to remove the work from the holding device. The last step in this operation is to place the part in a prescribed container, which will transport it for the next operation.

Similar to process analysis, operations analysis generates an operation sheet. It specifies the steps and elements of work for each operation. These are specified in the proper sequence, for example in the case of a manufacturing operation, detailed information such as required speeds and feeds of cutting tools, numbers and depth of cuts; and cycle time for the operation etc., are supplied. Set up instructions are also included with standard times for set up. Together, the 'route sheet' and the 'operation sheet' provide all the information required to perform a process effectively and efficiently.

7.7 Summary

- The world's markets and industry structures are in flux because the global forces at work are lowering the barriers to interaction. As interaction costs fall around the world, new economies of specialization, scale, and scope are being created—innovative companies have an abundance of opportunities to earn high rewards for the risks taken. Factories of the future are already in the making. FMS, CAD and CAM are cornerstones of the factory of the future.
- Typically, the CAM system is linked to CAD so that the product specifications drive the manufacturing specifications. The demand for CAM has grown rapidly because flexibility is required to meet the ever-changing competition and customer demand.
- While they are busy doing so, new paradigms are being created. Manufacturing Agility is a new paradigm and has been defined as an ability of a company to thrive in a competitive environment of continuous and unanticipated change. It differs from flexible manufacturing in the sense that flexible manufacturing is almost exclusively related to the change of a firm's internal hardware and software characteristics, while agile manufacturing organizations focus on products and processes.

7.8 Keywords

Analytic Processes: An analytic process breaks down a raw material into its constituent parts. An example is refining crude.

Assemble to Order (ATO): Assemble to order products are standard items that are assembled from in-stock subassemblies.

Notes

Engineer to Order (ETO): Engineer to order is to provide unique products that have not been previously engineered.

Flexible Manufacturing System: Flexible manufacturing system is a manufacturing system that consists of a number of CNC machine tools and a materials handling system that is controlled by one or more dedicated computers.

Lead Time: It is the interval between the start and end of an activity or series of activities. It measures the firm's responsiveness, quickness, and reliability.

Make to Order (MTO): Make to order products are made from previously engineered designs, but only are made after an order has been received.

Make to Stock (MTS): Make to Stock is when a seller stocks inventories of previously made products for purchase whenever the customer arrives.

Manufacturing Cell: Manufacturing cell is a self-sufficient unit, in which all operations to make a 'family' of parts, components or complete products can be carried out.

Manufacturing Flexibility: Manufacturing flexibility is the ability of a manufacturing system to respond, at a reasonable cost and at an appropriate speed, to planned and unanticipated changes in external and internal environments.

Modifying Processes: These processes modify the physical characteristics of materials upon which labor or operations are performed.

Process Improvement: Process improvement is the systematic study of the activities and flows of each process to improve it.

Process: A process is any part of an organization that takes inputs and transforms them into outputs.

Synthetic Processes: A synthetic process combines basic parts into larger products e.g. manufacture of automobiles, radios, televisions, etc.

7.9 Self Assessment

Fill in the blanks:

1. A .... is any part of an organization that takes inputs and transforms them into outputs.
2. .... refers to a storage area where the output of a stage is placed before being used in a downstream stage.
3. .... is when a seller stocks inventories of previously made products for purchase whenever the customer arrives.
4. .... products are standard items that are assembled from in-stock subassemblies.
5. Engineer to order is to provide .... that have not been previously engineered.

State whether the following statements are true or false:

6. Lead Time is the interval between the start and end of an activity or series of activities. It measures the firm's responsiveness, quickness, and reliability.
7. Buffering allows the stages to operate independently
8. A single-stage process normally requires to be buffered internally if the processes are not continuous.

Notes

9. The value the process generates is the difference between what the final product is worth to the customer and its initial value
10. Make to stock products are made from previously engineered designs, but only are made after an order has been received.

7.10 Review Questions

1. Describe the basic features of the five major process types and give an example of each type in (a) food business, (b) health care, and (c) manufacturing.

   Draw out the process diagrams of any two of the above.
2. "Companies are focusing on the things they do best and outsourcing all other functions to trusted partners." Explain this statement with examples from Indian Industry.
3. What is the difference between high-contact and low-contact systems? Provide some examples. Would a hotel such as Holiday Inn be classified as a high-contact operation if a customer on a business trip spends 8 of the 16 hours on the trip sleeping in the hotel?
   - (a) How does customer contact affect the operations strategy of a service organization?
   - (b) What implications do high-contact and low-contact systems have for efficiency, quality, flexibility, and dependability? Use the example of HMOs pressuring hospitals to reduce the average length of stay in order to reduce the cost of operations.
4. Describe the differences between process improvement and reengineering. When would you suggest a focus on process improvement? Under what conditions would you undertake a reengineering project?

Answers: Self Assessment

1. Process
2. Buffering
3. Make to Stock
4. Assemble to order
5. unique products
6. True
7. True
8. False
9. True
10. False

7.11 Further Readings

Books

Adam & Ebert, *Production and Operations Management – Concepts, Models and Behavior,* Prentice Hall of India, 1992.

Bradley Gale, *Managing Customer Value: Creating Quality and Service that Customers Can See*, Free Press, NY, 1994.

Budhiraja Sudeep, Piramal Gita, and Ghoshal Sumantra, *World Class in India: A Casebook of Companies in Transformation*, Penguin Books, 2003.

Kachru, Upendra, *Strategic Management–Concepts and Cases*, Excel Books, 2005.

Krajewski and Ritzman, *Operations Management, Strategy and Analysis*, Pearson Education; 2002.

Notes

Unit 8: Acceptance Sampling

CONTENTS

Objectives

After studying this unit, you will be able to:

- Describe the concept of acceptance sampling
- Explain the definition of lot acceptance sampling
- Discuss various types of sampling plans
- Analyse Type I and Type II Errors

Introduction

Acceptance sampling is used to determine whether to accept or reject a lot of material that has already been produced. By using the word a lot we mean a quantity of product accumulated under uniform conditions. For example the production of a man during one shift can be called a lot.

8.1 Acceptance Sampling

Acceptance sampling is an important field of statistical quality control that was popularized by Dodge and Romig and originally applied by the U.S. military to the testing of bullets during World War II. If every bullet was tested in advance, no bullets would be left to ship. If, on the other hand, none were tested, malfunctions might occur in the field of battle, with potentially disastrous results.

Acceptance sampling is "the middle of the road" approach between no inspection and 100% inspection. There are two major classifications of acceptance plans: by attributes ("go, no-go") and by variables. The attribute case is the most common for acceptance sampling, and will be assumed for the rest of this section.

Lot Acceptance Sampling

Notes

Dodge reasoned that a sample should be picked at random from the lot, and on the basis of information that was yielded by the sample, a decision should be made regarding the disposition of the lot. In general, the decision is either to accept or reject the lot. This process is called Lot Acceptance Sampling or just Acceptance Sampling.

A point to remember is that the main purpose of acceptance sampling is to decide whether or not the lot is likely to be acceptable, not to estimate the quality of the lot.

Notes ***Scenarios Leading to Acceptance Sampling***

Acceptance sampling is employed when one or several of the following hold:

1. Testing is destructive
2. The cost of 100% inspection is very high
3. 100% inspection takes too long

8.2 Acceptance Quality Control and Acceptance Sampling

It was pointed out by Harold Dodge in 1969 that Acceptance Quality Control is not the same as Acceptance Sampling. The latter depends on specific sampling plans, which when implemented indicate the conditions for acceptance or rejection of the immediate lot that is being inspected. The former may be implemented in the form of an Acceptance Control Chart. The control limits for the Acceptance Control Chart are computed using the specification limits and the standard deviation of what is being monitored.

In 1942, Dodge stated: "..basically the "acceptance quality control" system that was developed encompasses the concept of protecting the consumer from getting unacceptable defective product, and encouraging the producer in the use of process quality control by: varying the quantity and severity of acceptance inspections in direct relation to the importance of the characteristics inspected, and in the inverse relation to the goodness of the quality level as indication by those inspections."

To reiterate the difference in these two approaches: acceptance sampling plans are one-shot deals, which essentially test short-run effects. Quality control is of the long-run variety, and is part of a well-designed system for lot acceptance.

Ed Schilling (1989) said: "An individual sampling plan has much the effect of a lone sniper, while the sampling plan scheme can provide a fusillade in the battle for quality improvement."

Control of Product Quality using Acceptance Control Charts

According to the ISO standard on acceptance control charts (ISO 7966, 1993), an acceptance control chart combines consideration of control implications with elements of acceptance sampling. It is an appropriate tool for helping to make decisions with respect to process acceptance.

Notes The difference between acceptance sampling approaches and acceptance control charts is the emphasis on process acceptability rather than on product disposition decisions.

Notes

8.3 Lot Acceptance Sampling Plans (LASPs)

LASP is a sampling scheme and a set of rules A Lot Acceptance Sampling Plan (LASP) is a sampling scheme and a set of rules for making decisions. The decision, based on counting the number of defectives in a sample, can be to accept the lot, reject the lot, or even, for multiple or sequential sampling schemes, to take another sample and then repeat the decision process.

Types of LASPs

Types of acceptance plans to choose from LASPs fall into the following categories:

1. ***Single sampling plans:*** One sample of items is selected at random from a lot and the disposition of the lot is determined from the resulting information. These plans are usually denoted as (n,c) plans for a sample size n, where the lot is rejected if there are more than c defectives. These are the most common (and easiest) plans to use although not the most efficient in terms of average number of samples needed.
2. ***Double sampling plans:*** After the first sample is tested, there are three possibilities:
   (a) Accept the lot
   (b) Reject the lot
   (c) No decision

If the outcome is (3), and a second sample is taken, the procedure is to combine the results of both samples and make a final decision based on that information.

1. ***Multiple sampling plans:*** This is an extension of the double sampling plans where more than two samples are needed to reach a conclusion. The advantage of multiple sampling is smaller sample sizes.
2. ***Sequential sampling plans:*** This is the ultimate extension of multiple sampling where items are selected from a lot one at a time and after inspection of each item a decision is made to accept or reject the lot or select another unit.
3. ***Skip lot sampling plans:*** Skip lot sampling means that only a fraction of the submitted lots are inspected.

Definitions of basic Acceptance Sampling terms: Deriving a plan, within one of the categories listed above is discussed later. All derivations depend on the properties you want the plan to have. These are described using the following terms:

1. ***Acceptable Quality Level (AQL):*** The AQL is a percent defective that is the base line requirement for the quality of the producer's product. The producer would like to design a sampling plan such that there is a high probability of accepting a lot that has a defect level less than or equal to the AQL.
2. ***Lot Tolerance Percent Defective (LTPD):*** The LTPD is a designated high defect level that would be unacceptable to the consumer. The consumer would like the sampling plan to have a low probability of accepting a lot with a defect level as high as the LTPD.
3. ***Type I Error (Producer's Risk):*** This is the probability, for a given (n,c) sampling plan, of rejecting a lot that has a defect level equal to the AQL. The producer suffers when this occurs, because a lot with acceptable quality was rejected. The symbol α is commonly used for the Type I error and typical values for α range from 0.2 to 0.01.
4. ***Type II Error (Consumer's Risk):*** This is the probability, for a given (n,c) sampling plan, of accepting a lot with a defect level equal to the LTPD. The consumer suffers when this

Notes

occurs, because a lot with unacceptable quality was accepted. The symbol β is commonly used for the Type II error and typical values range from 0.2 to 0.01.

5. ***Operating Characteristic (OC) Curve:*** This curve plots the probability of accepting the lot (Y-axis) versus the lot fraction or percent defectives (X-axis). The OC curve is the primary tool for displaying and investigating the properties of a LASP.

6. ***Average Outgoing Quality (AOQ):*** A common procedure, when sampling and testing is non-destructive, is to 100% inspect rejected lots and replace all defectives with good units. In this case, all rejected lots are made perfect and the only defects left are those in lots that were accepted. AOQ's refer to the long-term defect level for this combined LASP and 100% inspection of rejected lots process. If all lots come in with a defect level of exactly p, and the OC curve for the chosen (n,c) LASP indicates a probability pa of accepting such a lot, over the long run the AOQ can easily be shown to be:

$$AOQ = \frac{p_a p(N - n)}{N}$$

   where N is the lot size.

7. ***Average Outgoing Quality Level (AOQL):*** A plot of the AOQ (Y-axis) versus the incoming lot p (X-axis) will start at 0 for p = 0, and return to 0 for p = 1 (where every lot is 100% inspected and rectified). In between, it will rise to a maximum. This maximum, which is the worst possible long term AOQ, is called the AOQL.

8. ***Average Total Inspection (ATI):*** When rejected lots are 100% inspected, it is easy to calculate the ATI if lots come consistently with a defect level of p. For a LASP (n,c) with a probability pa of accepting a lot with defect level p, we have

   ATI = n + (1 – pa) (N – n)

   where N is the lot size.

9. ***Average Sample Number (ASN):*** For a single sampling LASP (n,c) we know each and every lot has a sample of size n taken and inspected or tested. For double, multiple and sequential LASP's, the amount of sampling varies depending on the number of defects observed. For any given double, multiple or sequential plan, a long term ASN can be calculated assuming all lots come in with a defect level of p. A plot of the ASN, versus the incoming defect level p, describes the sampling efficiency of a given LASP scheme.

Task Prepare a study note on the concept of acceptance sampling and its uses in monitoring of the processes.

8.4 Making a Final Choice

Making a final choice between single or multiple sampling plans that have acceptable properties is a matter of deciding whether the average sampling savings gained by the various multiple sampling plans justifies the additional complexity of these plans and the uncertainty of not knowing how much sampling and inspection will be done on a day-by-day basis.

How do you Choose a Single Sampling Plan?

A single sampling plan, as previously defined, is specified by the pair of numbers (n, c). The sample size is n, and the lot is rejected if there are more than c defectives in the sample; otherwise the lot is accepted.

Notes

There are two widely used ways of picking (n,c):

1. Use tables (such as MIL STD 105D) that focus on either the AQL or the LTPD desired.
2. Specify 2 desired points on the OC curve and solve for the (n,c) that uniquely determines an OC curve going through these points.

8.5 Summary

- Sampling plans are typically set up with reference to an acceptable quality level, or AQL.
- The AQL is the base line requirement for the quality of the producer's product.
- The producer would like to design a sampling plan such that the OC curve yields a high probability of acceptance at the AQL.
- On the other side of the OC curve, the consumer wishes to be protected from accepting poor quality from the producer. So the consumer establishes a criterion, the lot tolerance percent defective or LTPD.
- Here the idea is to only accept poor quality product with a very low probability. Mil. Std. plans have been used for over 50 years to achieve these goals. SPC is preferred over Acceptance Sampling because it provides near real-time monitoring of the process.
- Acceptance sampling ignores the process and focuses exclusively on the output after it has been produced.

8.6 Keywords

Acceptable Quality Level (AQL): The AQL is a percent defective that is the base line requirement for the quality of the producer's product.

Average Outgoing Quality (AOQ): A common procedure, when sampling and testing is non-destructive, is to 100% inspect rejected lots and replace all defectives with good units.

Lot Tolerance Percent Defective (LTPD): The LTPD is a designated high defect level that would be unacceptable to the consumer. The consumer would like the sampling plan to have a low probability of accepting a lot with a defect level as high as the LTPD.

Multiple Sampling Plans: This is an extension of the double sampling plans where more than two samples are needed to reach a conclusion. The advantage of multiple sampling is smaller sample sizes.

Operating Characteristic (OC) Curve: This curve plots the probability of accepting the lot (Y-axis) versus the lot fraction or percent defectives (X-axis). The OC curve is the primary tool for displaying and investigating the properties of a LASP.

Sequential Sampling Plans: This is the ultimate extension of multiple sampling where items are selected from a lot one at a time and after inspection of each item a decision is made to accept or reject the lot or select another unit.

Skip lot Sampling Plans: Skip lot sampling means that only a fraction of the submitted lots are inspected.

8.7 Self Assessment

Fill in the blanks:

1. .... is used to determine whether to accept or reject a lot of material that has already been produced.
2. An .... has much the effect of a lone sniper, while the sampling plan scheme can provide a fusillade in the battle for quality improvement.
3. The difference between acceptance sampling approaches and .... is the emphasis on process acceptability rather than on product disposition decisions.
4. A .... is a sampling scheme and a set of rules for making decisions
5. .... is the ultimate extension of multiple sampling where items are selected from a lot one at a time and after inspection of each item a decision is made to accept or reject the lot or select another unit.

State whether the following statements are true or false:

6. Skip lot sampling means that only a fraction of the submitted lots are inspected.
7. The AQL is a percent defective that is the base line requirement for the quality of the producer's product
8. The LASP is a designated high defect level that would be unacceptable to the consumer
9. The OC curve is the primary tool for displaying and investigating the properties of a LASP.
10. The symbol α is commonly used for the Type I error and typical values for α range from 0.2 to 0.01.

8.8 Review Questions

1. What do you understand by the concept of acceptance sampling?
2. Write a note on the multiple sampling plan.
3. What are the Type I and Type II errors?

Answers: Self Assessment

1.	Acceptance sampling	2.	Individual sampling plan
3.	Acceptance control charts	4.	Lot Acceptance Sampling Plan (LASP)
5.	Sequential sampling plans	6.	True
7.	True	8.	False
9.	True	10.	True

Notes

8.9 Further Readings

Books

Adam & Ebert, *Production and Operations Management – Concepts, Models and Behavior,* Prentice Hall of India, 1992.

Bradley Gale, *Managing Customer Value: Creating Quality and Service that Customers Can See*, Free Press, NY, 1994.

Budhiraja Sudeep, Piramal Gita, and Ghoshal Sumantra, *World Class in India: A Casebook of Companies in Transformation*, Penguin Books, 2003.

Kachru, Upendra, *Strategic Management–Concepts and Cases*, Excel Books, 2005.

Krajewski and Ritzman, *Operations Management, Strategy and Analysis*, Pearson Education; 2002.

Unit 9: Inventory Planning and Control

Notes

CONTENTS

Objectives

After studying this unit, you will be able to:

- Understand inventory planning and inventory control
- Know about various functions and types of inventory
- Distinguish inventory costs, safety stock, order point and service level
- Learn about inventory control systems

Introduction

The term 'inventory' means any stock of direct or indirect material (raw materials or finished items or both) stocked in order to meet the expected and unexpected demand in the future. A basic purpose of supply chain management is to control inventory by managing the flows of materials. It sets policies and controls to monitor levels of inventory and determine what levels should be maintained, when stock should be replenished, and how large orders should be.

Inventory is a stock of materials used to satisfy customer demand or support the production of goods or services. By convention, inventory generally refers to items that contribute to or become part of an enterprise's output. There are different types of inventory; however, the most commonly identified types of inventory are:

1. ***Raw Materials Inventory:*** Parts and raw materials obtained from suppliers that are used in the production process.

Notes

2. ***Work-in-process (WIP) Inventory:*** This constitutes semi-finished parts, components, sub-assemblies or modules that have been inducted into the production process but not yet finished.
3. ***Finished Goods Inventory:*** Finished product or end-items.
4. ***Replacement Parts Inventory:*** Maintenance Parts meant to replace other parts in machinery or equipment, either the company's own or that of its customers.
5. ***Supplies Inventory:*** Parts or materials used to support the production process, but not usually a component of the product.
6. ***Transportation (pipeline) Inventory:*** Items that are in the distribution system but are in the process of being shipped from suppliers or to customers.

Manufacturing inventory is typically classified into raw materials, finished products, component parts, supplies, and work-in-process. In services, inventory generally refers to the tangible goods to be sold and the supplies necessary to administer the service.

In simple terms, inventory is an idle resource of an enterprise comprising physical stock of goods that is kept by an enterprise for future purposes.

9.1 Functions of Inventory

Though inventory is an idle resource, it is almost essential to keep some inventory in order to promote smooth and efficient running of business. To maintain independence of operations, a supply of materials at a work center allows that center flexibility in operations.

Consider the case – an enterprise that does not have any inventory. Clearly, as soon as the enterprise receives a sales order, it will have to order for raw materials to complete the order. This will keep the customers waiting. It is quite possible that sales may be lost. The enterprise may also have to pay a high price for various other reasons.

Another aspect relates to the costs for making each new production set up. Independence of workstations is desirable in intermittent processes and on assembly lines a well. As the time that it takes to do identical operations varies from one unit to the next, inventory allows management to reduce the number of set ups. This results in better performance.

Consider the case of seasonal items. Any fluctuation in demand can be met if possible, by either changing the rate of production or with inventories. However, if the fluctuation in demand is met by changing the rate of production, one has to take into account the different costs.

The cost of increasing production and employment level involves employment and training; additional staff and service activities; added shifts; and overtime costs. On the other hand, the cost of decreasing production and employment level involves unemployment compensation costs; other employee costs; staff, clerical and services activities; and idle time costs. By maintaining inventories, the average output can be fairly stable. The use of seasonal inventories can often give a better balance of these costs.

Inventory can be used, among other things, to promote sales by reducing customer's waiting time, improve work performance by reducing the number of set ups, or protect employment levels by minimizing the cost of changing the rate of production. Therefore, it is desirable to maintain inventories in order to enhance stability of production and employment levels.

If the demand for the product is known precisely, it may be possible (though not necessarily economical) to produce the product to exactly meet the demand. However, in the real world this does not happen and inventories become essential. Inventories also permit production planning for smoother flow and lower cost operation through larger lot-size production. They allow a buffer when delays occur. These delays can be for a variety of reasons: a normal variation in shipping time, a shortage of material at the vendor's plant, an unexpected strike in any part of the supply chain, a lost order, a natural catastrophe like a hurricane or floods, or perhaps a shipment of incorrect or defective materials.

Broadly speaking, some other functions of inventories are:

1. To protect against unpredictable variations (fluctuations) in demand and supply;
2. To take advantage of price discounts by bulk purchases;
3. To take advantage of batches and longer production run;
4. To provide flexibility to allow changes in production plans in view of changes in demands, etc; and
5. To facilitate intermittent production.

Only when considered in the light of all quality, customer service and economic factors – from the viewpoints of purchasing, manufacturing, sales and finance – does the whole picture of inventory become clear. No matter what the viewpoint, effective inventory management is essential to organizational competitiveness.

9.2 Inventory Costs

As inventory is a necessary but idle resource, inventory costs in manufacturing need to be minimized. The heart of inventory decisions lies in the identification of inventory costs and optimizing the costs relative to the operations of the organization. Therefore, an analysis of inventory is useful to determine the level of stocks. The resultant stock keeping decision specifies:

1. When items should be ordered?
2. How large the order should be?
3. "When" and "how many to deliver?"

It must be remembered that inventory is costly and large amounts of stocks are generally undesirable. Inventory can have a significant impact on both a company's productivity and its delivery time. Large holdings of inventory also cause long cycle times which may not be desirable as well. What are the costs identified with inventory? The following costs are generally associated with inventories:

9.2.1 Holding (or Carrying) Costs

It costs money to hold inventory. Such costs are called inventory holding costs or carrying costs. This broad category includes the costs for storage facilities, handling, insurance, pilferage, breakage, obsolescence, depreciation, taxes, and the opportunity cost of capital. Obviously, high holding costs tend to favor low inventory levels and frequent replenishment.

There is a differentiation between fixed and variable costs of holding inventory. Some of the costs will not change by increase or decrease in inventory levels, while some costs are dependent on the levels of inventory held.

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Notes **Fixed and Variable Holding Costs**

Fixed costs	Variable cost
Capital costs of warehouse or store	Cost of capital in inventory
Cost of operating the warehouse or store	Insurance on inventory value
Personnel costs	Losses due to obsolescence, theft, spoilage
	Cost of renting warehouse or storage space

9.2.2 Cost of Ordering

Although it costs money to hold inventory, it also, unfortunately, necessary to replenish inventory. These costs are called inventory ordering costs. Ordering costs have two components:

1. One component that is relatively fixed, and
2. Another component that will vary.

It is good to be able to clearly differentiate between those ordering costs that do not change much and those that are incurred each time an order is placed.

Notes The general breakdown between fixed and variable ordering costs is a follows:

Fixed and Variable Ordering Costs

Fixed costs	Variable costs
Staffing costs (payroll, benefits, etc)	Shipping costs
Fixed Costs on IT systems	Cost of placing and order (phone, postage, order forms)
Office Rental and equipment costs	Running costs of IT systems
Fixed Costs of Vendor Development	Receiving and inspection costs
	Variable Costs of Vendor Development

One major component of cost associated with inventory is the cost of replenishing it. If a part or raw material is ordered from outside suppliers, and orders are placed for a given part with its supplier three times per year instead of six times per year, the costs to the organization that would change are the variable costs, generally not the fixed costs.

There are costs incurred in maintaining and updating the information system, developing vendors, and evaluating capabilities of vendors. Ordering costs also include all the details, such as counting items and calculating order quantities. The costs associated with maintaining the system needed to track orders are also included in ordering costs. This includes phone calls, typing, postage, and so on.

Though vendor development is an ongoing process, it is a very expensive one. With a good vendor base, it is possible to enter into longer-term relationships to supply needs for perhaps the entire year. This changes the “when” to “how many to order” and brings about a reduction both in the complexity and costs of ordering.

9.2.3 Set up (or Production Change) Costs

Notes

In the case of sub-assemblies, or finished products that may be produced in-house, ordering cost is actually represented by the costs associated with changing over equipment from producing one item to producing another. This is usually referred to as set up costs.

Set up costs reflect the costs involved in obtaining the necessary materials, arranging specific equipment setups, filling out the required papers, appropriately charging time and materials, and moving out the previous stock of materials, in making each different product. If there were no costs or loss of time associated in changing from one product to another, many small lots would be produced, permitting reduction in inventory levels and the resultant savings in costs.

9.2.4 Shortage or Stock-out Costs

When the stock of an item is depleted, an order for that item must either wait until the stock is replenished or be canceled. There is a trade-off between carrying stock to satisfy demand and the costs resulting from stock out. The costs that are incurred as result of running out of stock are known as stock out or shortage costs. As a result of shortages, production as well as capacity can be lost, sales of goods may be lost, and finally customers can be lost.

In this context, it is important to understand the difference between dependent and independent demand. In manufacturing, inventory requirements are primarily derived from dependent demand; however, in retailing the requirements are basically dependent on independent demand.

Inventory systems are predicated on whether demand is derived from an end item or is related to the item itself. Because independent demand is uncertain, extra inventory needs to be carried to reduce the risk of stocking out.

To determine the quantities of independent items that must be produced, firms usually use a variety of techniques, including customer surveys, and forecasting. However, a balance is sometimes difficult to obtain, because it may not be possible to estimate lost profits, the effects of lost customers, or penalties for delayed order fulfillment.

Where the unfulfilled demand for the items can be satisfied at a later date (back order case), in such a case, the cost of back orders are assumed to vary directly with the shortage quantity (in rupee value) and the cost involved in the additional time required to fulfill the backorder (₹/₹/year). However, if the unfulfilled demand is lost, the cost of shortages is assumed to vary directly with the shortage quantity (₹/unit shortage). Frequently, the assumed shortage cost is little more than a guess, although it is usually possible to specify a range of such costs.

9.3 Inventory Control by Classification Systems

It is useful to visualize the inventory of a medium sized business organization. The inventory would comprise thousands of items, each item with different usage, price, lead time and specifications. There could be different procurement and technical problems associated with different items. In order to escape this quagmire, many selective inventory management techniques are used.

9.4 Inventory Control

Recent industry reports show that inventory costs as a percent of total logistics costs are increasing. Despite this rise, many organizations have not taken full advantage of ways to lower inventory costs. There are a number of proven strategies that will provide payoff in the inventory area, both in customer service and in financial terms.

Notes

Some of these strategies involve having fewer inventories while others involve owning less of the inventory. ERP and information technology solutions have been able to provide solutions, not only for inventory management but also for aggregate planning, material requirement planning and operations scheduling.

Regardless of which technique or solution one employs, proactive inventory management practices make a measurable difference in operations. In this supplement, we will cover some of the important inventory models and their characteristics, which are used in many of these ERP solutions.

Inventory Metrics

Managing inventory at manufacturing and service companies is critically important. Too much or too little, or the wrong inventory, all have detrimental impacts on operational and financial results.

Inventory represents a tremendous capital investment and also is an idle resource. Companies that can operate with lesser inventory are considered to operate more efficiently. Inventory measures reflect, in part, the success in structuring supplier relationships to optimize inventory at the buying company. Several aggregate performance measures can be used to judge how well a company is utilizing its inventory resources.

1. ***Average Inventory Investment:*** The rupee value of a company's average level of inventory is one of the most common measures of inventory. The information is easily available and it is easy to interpret. It represents the average investment of the company. However, it does not take into account the differences between companies. For example, a larger company will generally have more inventory than a smaller company, though it could be using its inventory more efficiently. This makes it difficult for the company to make comparisons with other companies.

2. ***Inventory Turnover Ratio:*** In order to overcome this problem, inventory turnover ratio is used. This measure allows for better comparison among companies. This is calculated as a ratio of the company's sales to its average inventory investment:

   Inventory turnover = Annual cost of goods sold/Average inventory investment

   This is a measure of how many times during a year the inventory turns over. Because it is a relative measure, companies of different sizes can be more easily compared. A higher turnover ratio reflects there are less idle resources in the company, and therefore the company is using its inventory efficiently. This ratio can only be used in this manner to compare companies that are similar. For example, even in the same industry depending on the distribution channels, a retailer would have a much lower inventory turnover ratio than the wholesaler or distributor.

3. ***Days of Inventory:*** A measure that tries to overcome the disadvantage, to a limited degree, and is closely related to inventory turnover is 'days of inventory'. This measure is an indication of approximately how many days of sales can be supplied solely from inventory. The lower this value, the more efficiently inventory is being used if customer demands are being met in full. There are two ways of calculating 'days of inventory'. It can be directly calculated, or inventory turnover can be converted to days of inventory. Both procedures are shown below:

   Days of inventory = Avg. inventory investment/ (Annual cost of goods sold/Days per year)

   Days of inventory = Days per year/Inventory turnover rate

Detailed measures of inventory accuracy and availability are very important in order to maximize manufacturing and non-manufacturing efficiency and financial results. In companies

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where consignment inventory programs have an important role, it is important to measure the performance of these programs.

Inventory obsolescence measures can be very important for items with short shelf lives, due to aging or technological changes.

Finally, collecting accurate data on which to construct inventory measures can be challenging. Processes have to be in place to ensure that inventory is counted accurately and on a timely basis.

9.5 Inventory Control Systems

An effective inventory control system should provide satisfactory answers to three questions:

1. How often should the assessment of stock on hand be made?
2. When should a replenishment order be placed?
3. What should be the size of the replenishment order?

In fixed quantity systems, the parameters that define a fixed reorder quantity system are 'Q', the fixed amount ordered at one time, and reorder point. These systems are common where a perpetual inventory record is kept or where the inventory level is under sufficiently close surveillance so that notice can be given when the reorder point has been reached.

In a 'time' triggered system, the inventory status is reviewed on a periodic basis, and an order is placed for an amount that will replenish inventories to a planned maximum level. The reorder quantity therefore varies from one review period to the next. The economic reorder cycle would then be EOQ/R, where R is the annual requirement.

Example: If EOQ = 10,000 units and annual requirements are R = 120,000 units, then the economic cycle would be 10,000/120,000 = 1/12 or 1 month.

One advantage of this system is that it sometimes makes operating efficiencies possible by reviewing the status of all items at the same time. However, inventory holding costs are usually higher than those associated with the continuous review system.

The following facts describe the important differences that determine the choice of the system that should be used:

1. The time triggered system requires less manpower to control. In the event triggered system, each item must be counted as it is issued or demanded. In the time triggered system, physical inventory count is taken only at the end of the period. This system is especially good for fast moving raw materials and supplies.
2. The time triggered system requires less calculating time than the event triggered system. In the event triggered system, each issue or demand from stock must be recorded and accounted for. Systemic costs i.e. the costs of running the system are generally less with the time triggered system.
3. The time triggered system may require more buffer stock to protect against uncertain demand and lead time. The reorder time is often non-optimal as it is fixed either weekly or monthly, and not based solely on economics, resulting in higher physical inventory costs.
4. The time triggered system runs the risk in more stock outs when unusually high fluctuation in demand occurs. When one or successive periods of unusually large demand occur, the event triggered system can react more quickly because it keeps track of net inventory with each unit demanded.

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Control systems sometimes combine regular review cycles and order points. In such systems, stock levels are reviewed on a periodic basis, but orders are placed only when inventories have fallen to a predetermined reorder level. Such systems combine the advantages of 'event' triggered and 'time' triggered review systems. These have the lowest total costs.

Task Prepare a study note on the concept of inventory control system.

9.6 Summary

- The manufacturing business environment, in most cases, is inherently unstable and turbulent. Change is the rule. The solution to minimizing inventory costs lies not in methods to stabilize and freeze the system but rather in an enhancement of the ability to accept change and to respond to it promptly and correctly. MRP systems backed by availability of computers provide just a unique such ability to respond to change. This idea has been incorporated in all ERP packages. These packages allow access to other databases or, ideally, the use of one common database.
- Separate databases create problems and delays in appropriate actions. Suppose we need to know the status of an order. The marketing database will probably show only information specific to marketing, such as the date the order was entered. If that order is in production, then production would be able to provide the status because that information would ordinarily not be in the marketing database. If the order has been completed and shipped, the shipping information would be with distribution or logistics.

9.7 Keywords

Fixed Order Quantity Systems: These are multiple period inventory models that are "event triggered", at an identified level of the stock the fixed-order quantity model initiates an order.

Functions of Inventory: It is essential to keep some inventory in order to promote smooth and efficient running of business.

Inventory Holding Costs: Costs involved in holding inventory, i.e., storage, handling, interest, breakage and pilferage etc., are called inventory-holding costs.

Single-Period Inventory Models: Single-period inventory models are a special case of periodic inventory systems based on how much risk we are willing to take for running out of inventory. These models are useful for a wide variety of service and manufacturing applications.

9.8 Self Assessment

State whether the following statements are true or false:

1. A group of people, that have been given leave to rest for a few days so that they can work effectively on next project, are a part of firm's inventory.
2. Goods that are kept at the port for boarding into the ships to send them off to the suppliers are also the part of inventory.
3. The need for inventories can be eliminated if the production rate is increased.
4. Inventories can also be a source of sales promotions.
5. Inventories don't allow flexibility in the production system as what is in stock only that has to be produced.

6. The transportation cost of raw materials is included in ordering costs.
7. For automobile major, Maruti Suzuki, Swift is an item that can be put in 'A' category as per ABC classification.
8. In services, replenishing inventories quickly is very important to keep customers satisfied.
9. In a general production situation, lead time can never be zero.
10. Economic Order Quantity concept was introduced by EW Taft in 1918.

Fill in the blanks:

11. A retail outlet lost 5 customers because they asked for RT Brand of soap, which was not available. This will lead to .... costs.
12. The pen and paper, used to note down the details of raw material inventory, are a part of .... inventory for the textile mill.
13. If the focus is more on the pricing of the items in inventory rather than on usage, then .... classification is used.
14. .... is reached at by calculating lead time * yearly level.
15. .... is order level that balances average fixed ordering costs and inventory holding costs.

9.9 Review Questions

1. Inventory control system may need to be modified as demand, costs, and competitive pressures changes. What are the parameters that should be reviewed for the fixed reorder quantity and periodic reorder systems?
2. What are the functions of inventory?
3. Annotate and analyse the term inventory costs.
4. Define inventory control by classification systems.
5. What do you understand by ABC classification and analysis?
6. Discuss the concept of inventory control systems.

Answers: Self Assessment

1.	True	2.	True
3.	False	4.	True
5.	False	6.	True
7.	True	8.	False
9.	True	10.	False
11.	Stockout	12.	Supplies
13.	HML	14.	Reorder Level
15.	Economic Production Quantity		

Notes

9.10 Further Readings

Books

Chunawala and Patil, *Productions and Operations Management*, Himalaya.

Everest E Adam & Albert, *Productions and Operations Management*, PHI Publications, 4th Ed.

Joseph G. Monks, *Operations Management (Theory & Problems)*, McGraw-Hill Intl.

S.N. Chary, *Productions and Operations Management*, TMH Publications.

Upendra Kachru, *Productions and Operations Management*, Excel Books, New Delhi.

Unit 10: Economic Order Quantity

Notes

CONTENTS

Objectives

After studying this unit, you will be able to:

- Describe the concept of fixed-order quantity system
- Explain the uses of economic order quality models
- Discuss schematic representation of the EOQ model

Introduction

The Economic Order Quantity Model is based on the assumptions that production is instantaneous. There is no capacity constraint and the entire lot is produced simultaneously.

In EOQ it is also assumed that delivery is immediate and there is no time lag between production and availability to satisfy demand. The demand is deterministic and there is no uncertainty about the quantity or timing of demand. The demand is constant over time, and in fact it can be represented as a straight line, so that if annual demand is 365 units, this translates into a daily demand of one unit. A production run incurs a constant setup cost and the products can be analysed singly. It means either there is only a single product or conditions exist that ensure reparability of products.

10.1 EOQ Model

The EOQ model provides a solution to the problem of determining when an order should be placed and how much should be ordered so as to minimize average annual variable costs. The

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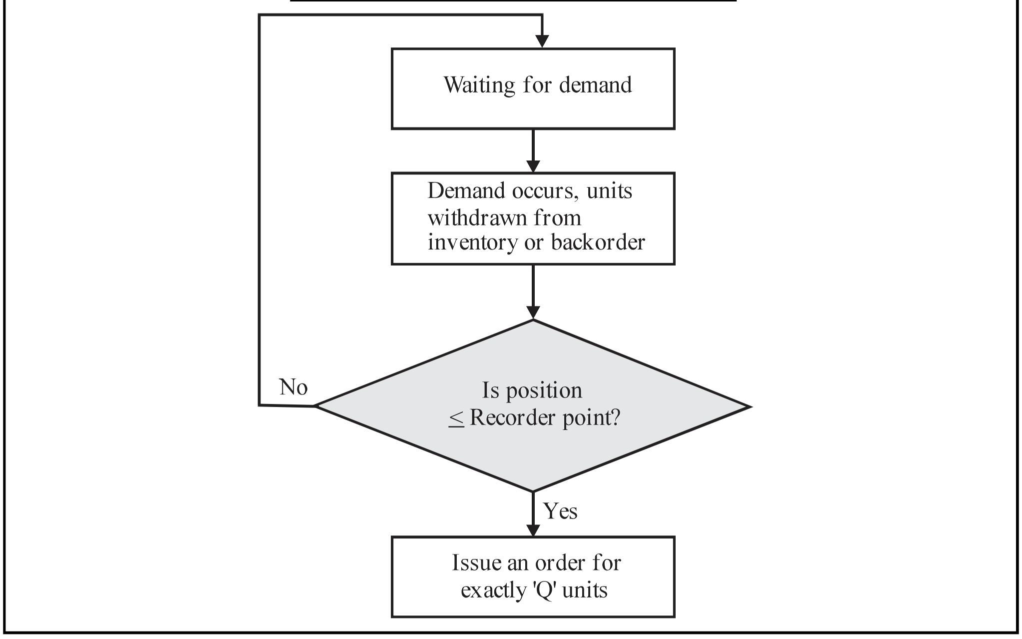
basic approach to determining fixed order sizes are shown by the Economic Order Quantity (EOQ) models. The basic EOQ model is concerned primarily with the cost of ordering and the cost of holding inventory.

A Fixed-Order Quantity system is shown in Figure 10.1.

Figure 10.1: Fixed Order Quantity System



Notes The notations that will be used in the models for this system are given below:

'D' – Annual demand

'v' – Unit purchase cost or unit cost of production (₹/unit)

'A' – Ordering or Set up cost (₹/year)

'r' – Holding cost per ₹ per year (₹/₹/year) (Inventory carrying charges Factor)

'b' – Shortage cost per ₹ short per unit time (₹/₹/year)

'Q' – Order quantity (to be determined)

The basic assumptions in the model are as follows:

1. The rate of demand for the item is deterministic and is a constant 'D' units per annum independent of time.
2. Production rate is infinite, i.e., production is instantaneous.
3. Shortages are not allowed.
4. Lead time is zero or constant and it is independent of both demand as well as the quantity ordered.
5. The entire quantity is delivered as a single package (or produced in a single run).

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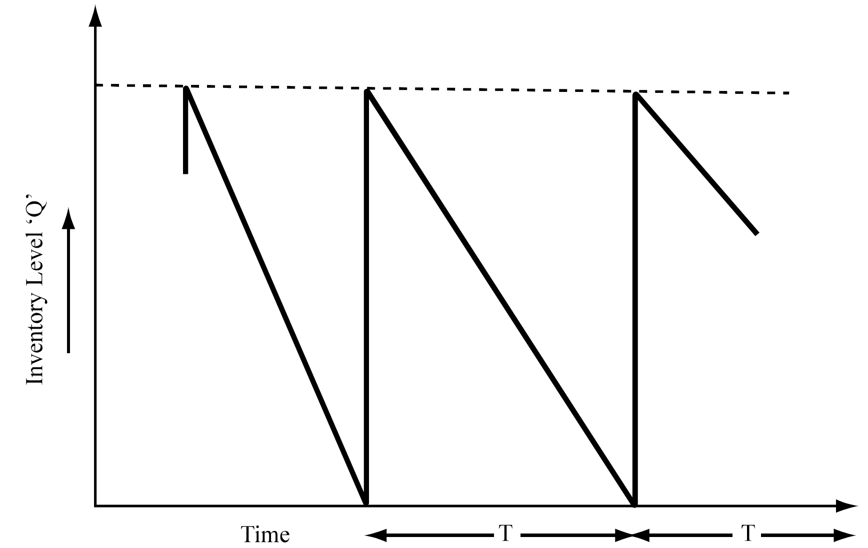
Figure 10.2: Schematic Representation of the EOQ Model



The objective of the model is to minimize the average annual variable costs, and it provides a solution to the problem of determining when an order should be placed and how much should be ordered. The schematic representation of the EOQ Model is given in Figure 10.2. It shows the 'inventory level' vs. 'time' relationship.

In developing the EOQ model, we will attempt to minimize total annual costs by varying the order quantity, or lot size. From the figure it is obvious that since the inventory is consumed at uniform rate and since maximum inventory level is Q, the average inventory will be 'Q / 2'.

Hence, average Investment in Inventory will be = 'Q*v/2'

And the Average Inventory Holding Cost will be = '(Q*v*r)/2'

Hence, the total annual variable cost (TC) = Ordering cost + Inventory Holding Cost.

Therefore,

$$TC = (A*D) / Q + (Q*v*r)/2$$

If 'Q^{EOQ}' is the order quantity at which the total cost is minimum, then mathematically the relationship can be expressed as:

$$Q = Q^{EOQ} = \sqrt{}\,(2*A*D / r*v),$$

This equation is known as the EOQ formula. From this formula, the optimal time between orders can be derived.

$$T^{EOQ} = D/Q = (1/D)*\sqrt{}\,(2*A*D/ r*v)$$

The Minimum Total Annual Cost (TC) of holding inventory is given by the formula:

$$TC = \sqrt{}\,2*A*D*r*v$$

Ordering cost and holding cost can be imagined as two children on a see saw. When one goes up, the other goes down, and vice versa. The way out of this dilemma is to combine the two costs as total annual variable costs and worry only about minimizing that cost.

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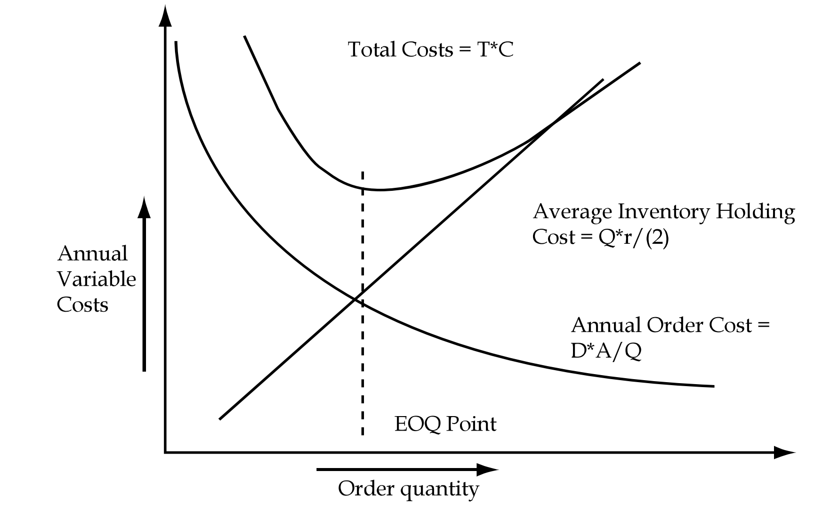
Figure 10.3 shows the relationship between order quantity and (a) Annual ordering cost; (b) Inventory Holding Cost; and (c) Total Annual Cost. You can see that there is just one point at which total costs are minimized.

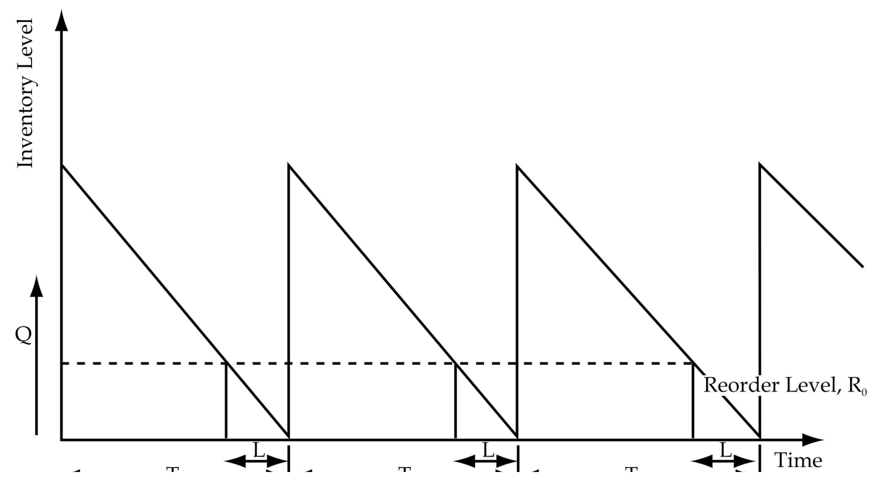
Figure 10.3: Total Annual Variable Costs



10.1.1 EOQ Model with 'Lead Time'

In the above discussion, we considered that lead time is zero. However, if lead time is constant, the above results can be used without any modification.

Figure 10.4: EOQ with a Fixed Lead Time Reorder Level



If lead time is constant and equal to 'L' (in weeks), then during lead time, the consumption is L*D units. This means order will have to be released for quantity Q^{EOQ}. The new order will arrive exactly after time period 'L' at which time inventory level will be zero and the system will repeat itself.

The inventory level at which the order is released is known as reorder level, as shown in Figure 10.4. It can be mathematically expressed by the equation:

$$\text{Reorder Level} = R_o = L*D$$

Notes

Example: Understand the EOQ Model and all that has been said earlier in this section on fixed order quantity policies:

A company, for one of its class 'A' items, placed 8 orders each for a lot of 150 numbers, in a year. Given that the ordering cost is ₹ 5,400.00, the inventory holding cost is 40 percent, and the cost per unit is ₹ 40.00. Find out if the company is making a loss in not using the EOQ Model for order quantity policies.

What are your recommendations for ordering the item in the future? And what should be the reorder level, if the lead time to deliver the item is 6 months?

'D' = Annual demand = 8*150 = 1200 units

'v' = Unit purchase cost = ₹ 40.00

'A' = Ordering Cost = ₹ 5400.00

'r' = Holding Cost = 40%

Using the Economic Order Equation:

$Q^{EOQ} = \sqrt{} (2*A*D / r*v)$

$\sqrt{} (2 *5400*1200)/(0.40*40)$ = 900 units.

Minimum Total Annual Cost (TC) $= \sqrt{} 2*A*D*r*v$

$= \sqrt{} 2*5400*1200*0.40*40$

= ₹ 14,400.00

The Total Annual Cost under the present system = ₹ (1200*5400/150 + 0.40*40*150/2)

= ₹ (43,800 + 1200) = ₹ 45,000.00

The loss to the company = ₹ 45,000 – ₹ 14,400 = ₹ 30,600.00

Reorder Level (R_o) = L*D = (6/12)* 1200 = 600 units

The company should place orders for economic lot sizes of 900 units in each order. It should have a reorder level at 600 units.

Sensitivity Analysis

In the models that we have discussed in this section, we have assumed as if the various parameters are used such as demand 'D', inventory carrying charges factor 'r' ordering or set up cost 'A', are known. In real life situations, the value that is used is often an estimate which may be different from the real value due to a number of causes. Due to practical reasons, it is important to test the results of the EOQ model and find how sensitive the results are to the changes in various parameters.

The sensitivity can be explored in various ways. Let us assume that the estimated values of parameters differ from "true" values by some factor 'k'. The average inventory will be 'I'. The estimated holding cost is 'm*r' and the estimated ordering cost is 'l*A'. The estimated purchasing cost is 'n*v'. Then the ratio of the estimated optimal cost and the "true" optimal cost will be given by the equation:

$TC_e/TC = (1/2)*[(\sqrt{} m*n/l*k) + \sqrt{} (l*k/m*n)]$

To examine the sensitivity of the costs to the errors in estimation of parameters, let us consider a situation where the estimates of 'A', 'r' and 'v' are correct, i.e., they all correspond to the "true"

Notes

value. This means, l = m = n = 1. However, the estimate of demand turns out to be 50 per cent higher than the true demand, i.e., 'k = 1.5'.

Now putting these values into the equation, we can find the ratio of actual cost to "true" cost for this case.

$$TC_e/TC = 1/2\ [\sqrt{1.5/1} + \sqrt{1/1.5}] = 1.020$$

If the same example is considered, but if we assume that demand is 50 per cent on the lower side of "true demand then, 'k = 0.5' – we already know that l = m = n = 1 as before:

$$TC_e\ /\ TC = 1/2\ [\sqrt{0.5/1} + \sqrt{1/0.5}] = 1.060$$

The results show that if the estimate of demand is 50% on the high side of the "true" value of demand, the increase in cost over the "true" optimal cost is only 2.0 per cent; and if estimated demand is 50 percent on the lower side, then the increase in cost over "true" optimal cost will be 6.00 per cent.

It shows that in the EOQ model, cost is quite insensitive to the errors on the higher or lower side of demand estimation. However, it is also clear from the calculations that insensitivity is more for the same magnitude of error on the higher side than for the error on the lower side.

Also, as the parameters are symmetrically arranged in the 'TC_e/TC equation', the same conclusion can be drawn for the other parameters, i.e., l, m and n. Since k*l and m*n appear in ratio in 'TC_e/TC equation', any error in the numerator or denominator of the same magnitude and direction will cancel each other out, whereas errors in the opposite direction will be magnified. Therefore, it will be advantageous to overestimate 'm' and 'n', if 'k' and 'l' are likely to be overestimated and underestimated if 'k' and 'l' are likely to be underestimated.

Notes We can see from the mathematical derivations of the EOQ equations that:

1. For similar magnitudes, overestimation is preferable to underestimation of parameters.
2. If 'k' and 'l' are likely to be overestimated, then it is better to overestimate 'm' and 'n', since errors cancel out when they are in same direction.
3. In general, the total cost is quite insensitive to errors in estimation of parameters.

Economic Order Quantity Model with Shortages: This model considers the situation when back orders are allowed, i.e., stock out is allowed for some period in the system. In case of shortage, demand is assumed to reflect as a back-order and is not lost. The model assumes three costs, unlike the earlier model that assumed only the first two costs shown below:

1. Ordering or set up cost,
2. Inventory holding cost, and
3. Shortage or stock out cost.

The shortage cost is denoted by 'b' rupees per ₹ short per unit time, i.e., ₹/₹/Year.

The total average annual cost (TC) can be written as,

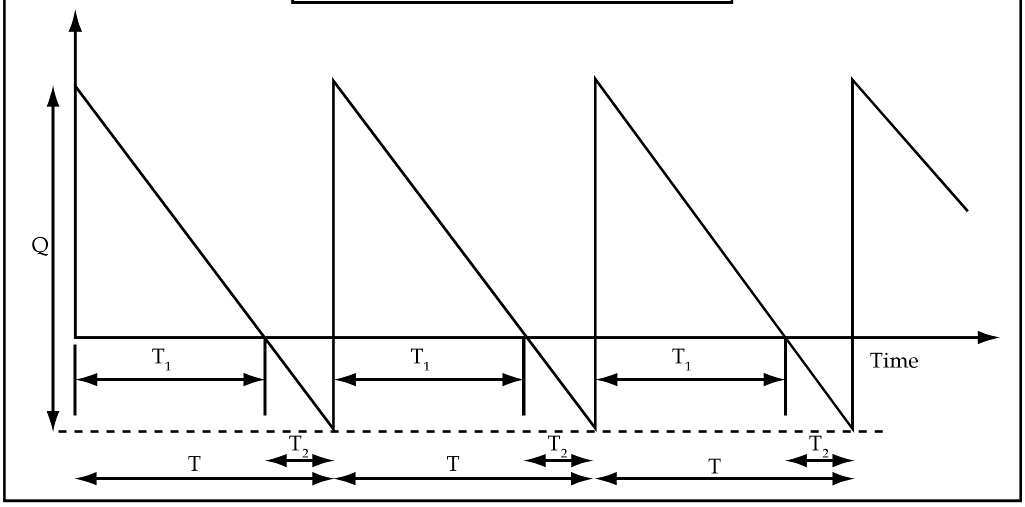
TC = Ordering cost + Inventory holding cost + Cost of back orders

Assuming order quantity to be 'Q', then the number of orders per annum equals 'D/Q' And hence ordering cost equals 'A* (D/Q)'.

Total Annual Cost (with backorders permitted) = $[(Q-S)^2 *v*r /2Q] + A* (D/Q) + S^{*2} *b/2* Q^{EOQ}]$

Notes

Figure 10.5: EOQ Model with Shortages



The average inventory and stock out can be derived using Figure 10.5. The average inventory during period T_1 will be 'I' (as consumption is at uniform rate) and the inventory level during T_2 is negative and hence, in practice, on hand inventory will be zero.

Thus, average inventory through period T will be

Average Inventory $= (Q - S)^2 / 2Q$

Average Inventory Holding Cost $= [(Q - S)^2 / 2Q] * v * r$

and, $Q^{EOQ} = \sqrt{(2*A*D/ r*v)*((r*v + b)/ b)}$

If shortages are not allowed, then $b = \infty$

The above equation will be reduced to: $Q = Q^{EOQ} = \sqrt{2*A*D/r*v}$

This is the same equation that we had derived earlier, i.e., optimal order quantity for the EOQ model.

Let us try another exercise to demonstrate the EOQ model.

Example: The demand for an item is equal to 600 units per year. The per unit cost of the item is ₹ 50 and the cost of placing an order is ₹5. The inventory carrying cost is 20% of inventory per annum and the cost of shortage is Re. 1 per unit per month. Find the optimum ordering quantity if stock outs are permitted. If stock outs are not permitted, what would be the loss to the company?

'D' = Annual demand = 600 units

'v' = Unit purchase cost = ₹ 50.00

'A' = Ordering Cost = ₹ 5.00 per order

'r' = Holding Cost = 20% per annum

'b' = Shortage Cost = ₹ 12 per annum

$Q^{EOQ} = \sqrt{(2*A*D/ r*v)*((r*v + b)/ b)}$

$= \sqrt{(2*5*600/0.20*50)*((0.20*50 +12)/12)}$

$= \sqrt{600*1.833} = 33.16$ units = say 33 units

Notes

Max. Number of backorders (S*) = Q^{EOQ} (r*v/(r*v + b)

= 33* (0.20*50/((0.20*50) +12) = 15 units

Total Annual Cost (with backorders permitted) = [(Q-S)^2 *v*r /2Q] + A* (D/Q) + S*^{2} *b/2* Q^{EOQ}

= [(33 -15)^2 *(0.20*50) / (2*33)] + (600*5)/33 + 15*15*12/ (2*33)

= ₹ 181

If stock outs and backorders are not permitted, the economic order quantity is:

Q = Q^{EOQ} = √2*A*D/r*v

= √ 2*600*5/ (0.20*50) = 24.5 units

TC = Ordering Cost + Ave. Holding Cost = [D*A/ Q^{EOQ}] + Q^{EOQ} * r*v/2

= [600*5/ 24.5)] + 24.5*0.20*50/2 = ₹ 254.00

Therefore, additional cost when backordering is not allowed = 254.00 – 181.00

= ₹ 64.00

10.1.2 Fixed-time Period Models

In many retail merchandising systems, a fixed-time period system is used. Sales people make routine visits to customers and take orders for their complete line of products. Inventory, therefore, is counted only at particular times, such as every week or every month or when the supplier's visit is due. Sometimes, this is also resorted to in order 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. A Fixed-Period Quantity system is shown in figure 17.6. These generally require a higher level of safety stock than fixed-order quantity systems, which require continual tracking of inventory on hand and replenishing stock when the reorder point is reached. In contrast, the standard fixed-time period models assume that inventory is counted only at the time specified for review.

The risk associated with this system is that it is possible that some large demand will draw the stock down to zero right after an order is placed. There is no remedy for such a situation and the condition could go unnoticed until the next review period. Even after placement of new orders, the item may still take time to arrive.

This highlights the high probability of being out of stock throughout the entire review period and order lead time. Safety stock, therefore, is an extremely important requirement for these systems and is used to effectively protect against the high probability of stock outs.

10.1.3 Fixed-time Period Model with Safety Stock

Continuing our discussions on Fixed-time Period models, it is essential that 'safety stock' is a consideration in model building. We will discuss below a fixed-time period system with safety stock.

The notations that will be used in the model are given below:

q = Quantity to be ordered

T = Number of days between reviews

L = Lead time in days (time between placing an order and receiving it)

Notes

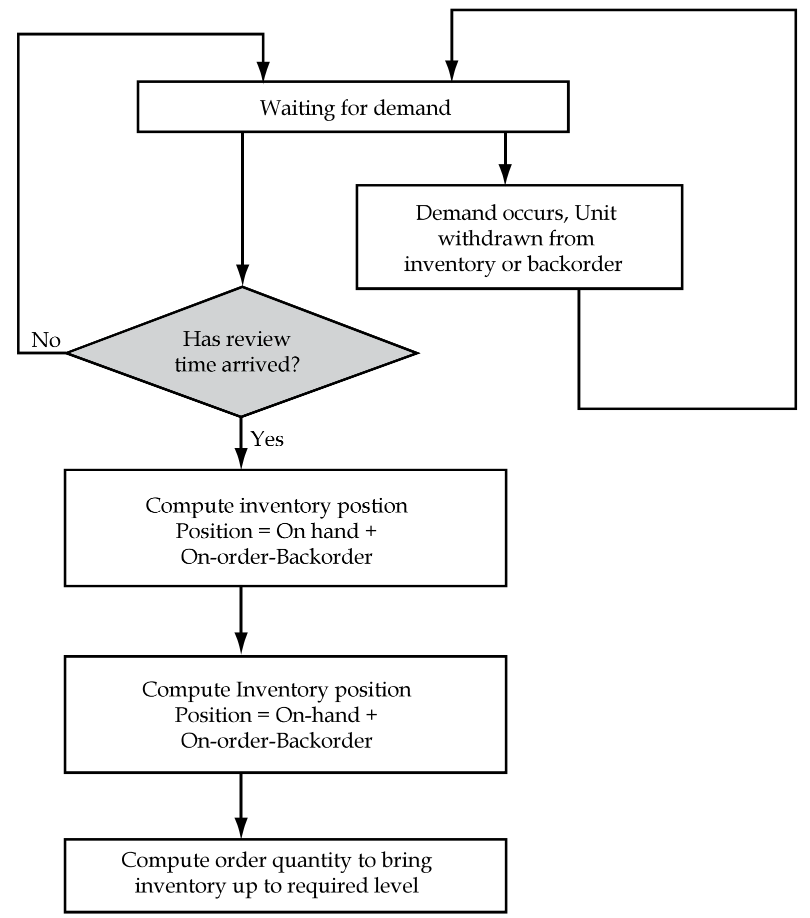
D = Forecast average daily demand

z = Number of standard deviations for a specified service probability

σ_{T+L} = Standard deviation of demand over the review and lead time

I = Current inventory level (includes items on order)

Figure 10.6: Fixed-time Period Quantity System



Reorders are placed at the time of review 'T', and the safety stock has to be a function of the level of service desired and lead time. Accordingly, the quantity that must be reordered is:

$$\text{Safety Stock} = z^* \sigma_{T+L}$$

Notes

Figure 10.7: Fixed Time Period Model with Safety Stock

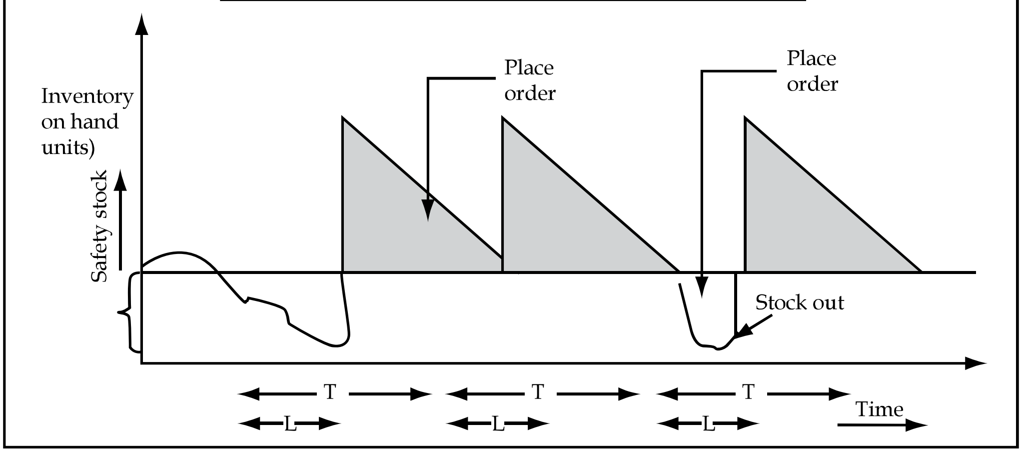


Figure 10.7 shows a fixed-time period system with a review cycle of 'T' and constant lead time of 'L'. Demand is assumed to be normally distributed and randomly distributed about a mean 'd' and the quantity to order 'q', is given by the relationship:

Order Quantity = Average demand over the vulnerable period + safety stock - Inventory currently on hand

Or $q = d^*(T + L) + z^* \sigma_{T+L} - I$

In this model, demand (d) can be forecast and revised each review period if desired or the yearly average may be used if appropriate. The value of z is dependent on the probability of stocking out and can be found using the Excel NORMSINV function discussed earlier.

Notes A comparison between the two systems; (a) Fixed-order Quantity System and (b) Fixed-time Quantity System is given in table.

Comparison of Different Inventory Ordering Systems

S. No.	Fixed Order Quantity System	Fixed Time Quantity System
1.	The order quantity is fixed	The re-order data is fixed.
2.	The order is placed when the inventory drops tore-order level.	The re-order quantity varies according to inventory on hand.
3.	It is most suitable when carrying cost is measurable and significant.	It is suitable when the carrying cost is meaningless and insignificant
4.	It is preferred when the supplier places a minimum order quantity restriction.	It is preferred when the supplier will only ship at fixed date.
5.	It is suitable for A class items having a high unit cost	It is suitable for B and C class items.

Example: Novelty Ltd carries a wide assortment of items for its customers. One item, Gaylook, is very popular. Desirous of keeping its inventory under control, a decision is taken to order only the optimal economic quantity, for this item, each time. You have the following information. Make your recommendations:

Annual demand : 1,60,000 units

Price per unit : ₹20

Carrying cost : ₹1 per unit or 5 per cent per rupee of inventory value

Cost per order : ₹ 50

Determine the optimal economic quantity by developing the following table

Size of order	1	10	20	40	80	100
No. of orders						
Average inventory						
Carrying costs						
Order costs						
Total costs						

Solution:

Let us attack the problem using a tabular approach.

We know the requirement, carrying cost and ordering cost. These have been appropriated in the table below:

Order per year	Lot size	Average inventory	Carrying cost (₹1)	Ordering cost (₹50 per order)	Total cost per year
1	1,60,000	80,000	80,000	50	80,000
10	16,000	8,000	8,000	500	8,500
40	8,000	4,000	4,000	1,000	5,000
80	4,000	2,000	2,000	2,000	4,000
100	2,000	2,000	1,000	4,000	5,000
	1,600	800	800	5,000	5,800

The optimum economic quantity (lot size) for this item is 4,000 numbers.

Example: A manufacturer has to supply his customers 600 units of his product per year. Shortages are not allowed and the inventory carrying cost amount to ₹0.60 per unit year. The setup cost per run is ₹/.80. Find:

1. The Economic order Quantity.
2. The minimum average yearly cost.
3. The optimum number of orders per year,
4. The optimum period of supply per optimum order
5. The increase in the total cost associated with ordering 20 per cent more than EOQ.

Solution:

We are given:

D = Total number of unit supplied per unit time period = 600 units

A = Set-up cost per run = ₹ 80

R = Inventory carrying cost per unit per year = ₹0.60.

1. Economic order quantity is given by:

$$Q^{EOQ} = \sqrt{(2DA / r)}$$

$$= \sqrt{[(2 \times 600 \times 80) / 0.60]} = 400 \text{ units}$$

Notes

2. Minimum average yearly cost is given by:

$$T^{EOQ} = (D \times A) / Q^{EOQ} + (Q^{EOQ} \times r) / 2$$

$$= (600 \times 80) / 400 + (400 \times 0.60) / 2$$

$$= ₹240.$$

3. The optimum number of orders per year is:

$$N^{EOQ} = D/Q^{EOQ} = 600/ 400 = 3/2$$

4. The optimum period of supply per optimum order is

$$T^{EOQ} = 1 / N^{EOQ} = 1 / (3 / 2)$$

$$= 2 / 3$$

5. Ordering 20% higher than EOQ:

Ordering quantity = (120 × 400) / 100 = 480 units

With

$$Q^{EOQ} = 400 \text{ and } Q = 480,$$

The ratio $k = Q / Q^{EOQ} = 480/400 = 1.2$

We have

$$T^{Q}/T^{EOQ} = [(1 / k + k) /2]$$

$$= (1 / 1.2 + 1.2)/2$$

$$= 61 / 60$$

Thus the cost would increase by 1/60th

Or 240 × 1/60 = ₹4

Task 'Shortages are undesirable, but some organizations create shortages intentionally'. How is this justified from an economic point of view? Derive an expression for total cost in the inventory model for intentional shortages.

10.2 More Complex Models

For simple inventory models, we assumed that future demand is known with certainty. Generally, however, this is not the case for companies like BPCL. The demand varies from day to day as well from period to period. Making things, even more complex is the fact that BPCL provides a principle product that is not distinguishable from similar products provided by other 'oil' companies. In such cases Stochastic Inventory Models need to be used. But before that we will look into stochastic models where the selling price of an item varies with the order size, and how this is handled in inventory management.

10.2.1 Quantity Discounts or Price-break Models

Each of us has purchased goods in larger quantities than we immediately need so that we could pay a lower unit price. When demand is certain, delivery is instantaneous (no stock outs), and

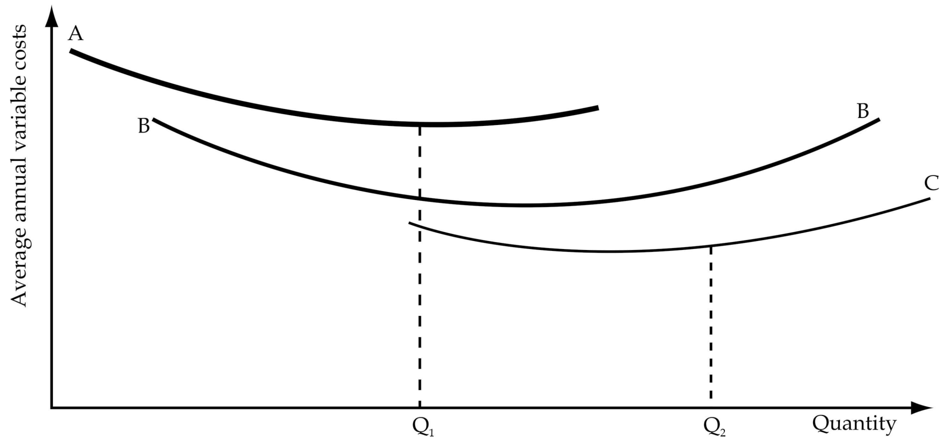
Notes

item cost varies with volume ordered, the result is a modified simple lot size situation called the quantity volume case or price break model.

The model assumes a discrete or step change rather than a per-unit change. For example, a Classic cigarette sold from an open packet will cost ₹ 3.50 each. If purchased as a packet of 20, it would cost ₹ 65.00. However, if you buy a carton of 10 packets it will only cost ₹ 600.00. To determine the optimal quantity of cigarettes you want to buy, the model simply solves for the economic order quantity for each price and at the point of price change.

Figure 10.8 represents this concept. For 3 items, A, B, and C, a manufacturer offers price discounts. For items 'A' and 'B' at quantities equal to or greater than 'Q_1' and for item 'C' for a quantity equal to or greater than 'Q_2'. The average annual variable costs are reflected by the curves 'AA', 'BB' and 'CC'.

Figure 10.8: Quantity Discounts: Price Breaks are Given at Quantities Q_1 and Q_2



The general procedure for determining the order quantity starts by checking the lowest cost curve for an optimal Q^{EOQ}. If that is unsuccessful, each higher cost curve is systematically checked until the optimal Q^{EOQ} is found. The total cost for each feasible economic order quantity and price-break order quantity is tabulated, and the Q that leads to the minimum cost is the optimal order size or the Q^{EOQ} for the given item.

If the holding costs of the company are based on a percentage of unit prices, the largest order quantity, which is also the lowest unit price, is solved first. The Q^{EOQ} that is determined should be valid. If it is not, the next-largest order quantity is examined till a feasible solution is found. The cost of this Q^{EOQ} is compared to the cost of using the order quantity at the price break, and the lowest cost determines the Q^{EOQ}.

10.2.2 Variable Demand and Constant Lead Time

We will now examine a moderately complex quantity/reorder point model in which lead time does not vary, but demand does. This model is shown in Figure 10.9. In this model, we take into account the possibility of a stock out. The model establishes buffer stocks that adequately protect service to customers when demand is uncertain. The notations that are used in the model are given below:

μ = Demand during lead time, a random variable

σ_u = Standard deviation of demand during lead time

$\bar{\mu}$ = Expected demand during lead time

Notes

$\bar{d}$ = Expected average daily demand

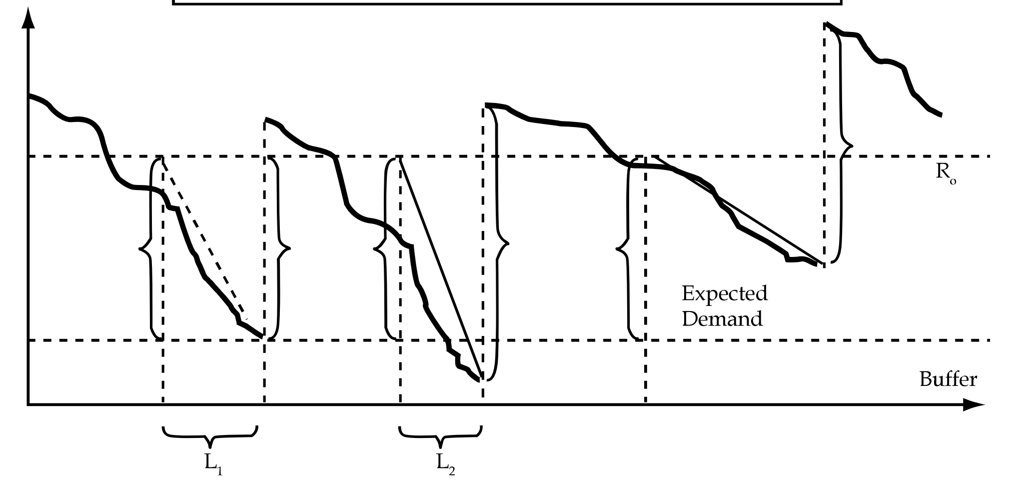
σ_d = Standard deviation of expected daily demand

$\bar{D}$ = Expected annual demand

B = Buffer stock

z = Number of standard deviations needed for a specified confidence level

Figure 10.9: Variable Demand with Constant Lead Time Model



You can see from Figure 10.9, that the expected lead-time demand 'u' plus the buffer stock 'B' equals the reorder level R_o. Second, we also know that the lead time 'L' is constant, which is an assumption for the model. And, the buffer stock is a function of the variation in demand 'σ_u' and the protection level specified to maintain the confidence level, i.e. 'z'. Therefore, the expected lead-time demand equals expected demand times lead time:

$$R_o = \bar{\mu} * B, \text{ and 'B' is '} z*\sigma_u \text{' for the specified service level}$$

And $\bar{\mu} = \bar{d} * L,$

Therefore, $R^* = \bar{d} * L + z*\sigma_u$

The order quantity is simply the simple lost size formula with expected annual demand substituted for annual demand:

$$Q = Q^{EOQ} = \sqrt{2*A*\bar{D}/r*v}$$

Generally, average demand is used for this model regardless of the distribution of the demand function.

10.2.3 Variable Demands and Lead Times

When both demand and lead times are probabilistic, the basic procedure for finding operating doctrines is a convergence procedure. This is a directed trial an error method. For the quantity/reorder point model, the order quantity is computed assuming constant demand. Then the reorder point is calculated using the computed order quantity. This value is then used to recalculate the order quantity and recalculate the reorder point. Eventually, the order quantity the reorder point coverage to their optimal values.

This type of trial and error computation is best carried out using a computer.

10.3 Summary

- Because of the separate databases, no one in any area of the company has access to all company information. Another problem with separate databases is that they may contain conflicting information, due to many possible reasons. The purpose of ERP is to avoid these problems by combining all these separate databases into one common database for the entire organization, and possibly even for the entire supply chain.
- The advantages that accrue from this approach is that any one any where within the organization has access to all information and there is an increase speed in retrieving information. Extending this idea to an entire supply chain, the advantages become obvious. All members of the supply chain have access to the same information and can utilize the same information for purposes of planning and execution. Not only does this make planning and forecasting simpler, some companies report reducing inventory levels through to the supply chain by 50 per cent or more.
- In the brave new world of networking data, we are moving from point of purchase to point of use, which gets buyers and sellers much closer to what they both want and need. Global manufacturing excellence will soon be measured against anticipation—how early can you know what consumers want? How early can you deliver it? That's the new demand-driven supply chain, and the global future.

10.4 Keywords

Christmas Tree Problem: This type of problem occurs where demand is probabilistic. In such cases policies are based on the probability of the occurrence of the particular event rather than actual costs.

Economic Order Quantity (EOQ) Models: The basic approach to determining fixed order sizes—are the Economic Order Quantity (EOQ) models. The basic EOQ model is concerned primarily with the cost of ordering and the cost of holding inventory.

Fixed Time Quantity Systems: These systems are "time triggered", at an identified fixed time the fixed-time quantity model initiates an order to replenish the stock.

Price-Break Models: When item cost varies with volume ordered, the result is a modified simple lot size situation called the quantity volume case or price break model.

Re-order Level: The inventory level at which the order is released is known as the reorder level.

10.5 Self Assessment

Fill in the blanks:

1. The .... is based on the assumptions that production is instantaneous
2. A production run incurs a .... and the products can be analysed singly.
3. The .... is deterministic and there is no uncertainty about the quantity or timing of demand.
4. The EOQ model provides a solution to the problem of determining when an order should be placed and how much should be ordered so as to ....
5. The basic EOQ model is concerned primarily with the cost of ordering and the cost of ....
6. .... generate order quantities that vary from period to period, depending on the usage rates

Notes

7. When both demand and lead times are ...., the basic procedure for finding operating doctrines is a convergence procedure.
8. For the quantity/reorder point model, the order quantity is computed assuming ....
9. The inventory level at which the order is released is known as the ....
10. The .... the reorder point coverage to their optimal values.

10.6 Review Questions

1. What is Economic Order Quantity (EOQ)? Explain the EOQ model of inventory with its simplifying assumptions. How is the model of inventory used by a manufacturer different from a retailer?
2. What is the cost of uncertainty in demand during lead time?
3. Nuvyug Industries Ltd. has an annual requirement of 5,000 pieces of brake cylinders for its popular brand of golf carts. Each brake cylinder has a carrying cost of ₹ 25 per unit per year. The Ordering Cost per order is ₹ 800. Calculate the total inventory cost for the following values of number of orders: 5, 10, 20, and 25. Plot the various costs with respect to these orders on a graph and use it to find the EOQ.
4. Hindustan Levers is a manufacturer of the Surf detergent powder. A 100-g pack of its detergent power is priced at ₹ 30 for its suppliers. One of its suppliers purchases 16,000 packs per annum. The suppler incurs an ordering cost of ₹ 350.00 per order and has a carrying cost of 12% of the inventory value. Hindustan Levers offers discounts for the following ranges of bulk purchases to its suppliers: 0.5% for 3,000 - 6,999 units, 0.75% for 7000 – 9,999 units and 1% for 10,000 and more units. Which discount option should the supplier choose? What is the EOQ in this case?

Answers: Self Assessment

1. Economic Order Quantity Model
2. Constant setup cost
3. Demand
4. Minimize average annual variable costs
5. Holding inventory
6. Fixed-time period models
7. Probabilistic
8. Constant demand
9. Reorder level.
10. Order quantity

10.7 Further Readings

Books

Chunawala and Patil, *Productions and Operations Management*, Himalaya.

Everest E Adam & Elbert, *Productions and Operations Management*, PHI Publications, 4th Ed.

Joseph G. Monks, *Operations Management (Theory & Problems)*, McGraw-Hill Intl.

S.N. Chary, *Productions and Operations Management*, TMH Publications.

Upendra Kachru, *Productions and Operations Management*, Excel Books, New Delhi.

Unit 11: Inventory Model

Notes

CONTENTS

Objectives

After studying this unit, you will be able to:

- Define Quantity Discounts or Price-Break Models
- Explain Variable Demand and Constant Lead Time
- Describe Uncertainty in Demand and Lead Time
- Discuss Model with Specified Service Levels
- Define Variable Demands and Lead Times

Introduction

Inventory models seek to optimize the costs associated with investing in an idle resource. There are 'single period' and 'multiple period' inventory models. We will begin with single period inventory models.

11.1 Single Period Models

This is a special case of periodic inventory system, as opposed to a perpetual inventory system. Consider the problem that a florist stationed outside a 5-Star hotel has. Every morning, the wholesaler's truck comes to him and he has to decide how many flowers to buy. If he does not have enough flowers in the stand, some customers will not be able to purchase flowers and the florist will lose the profit associated with these sales. On the other hand, if he stocks too many flowers he will not be able to sell them tomorrow as they will spoil. He will have paid for flowers that remain unsold, adversely impacting the day's profits.

Actually, this is a very common type of problem for all products that are perishable or have very low shelf lives. This includes both goods as well as services. A simple way to think about this is to consider how much risk we are willing to take for running out of inventory.

Notes

The classical case illustrated in most texts is the 'newspaper seller's dilemma'. Let's take the example where the newspaper vendor has collected data over a few months that show that each Sunday, on an average, 100 papers were sold with a standard deviation of 10 papers. With this data, it is possible for our newspaper vendor to state a service rate that he feels is acceptable to him. For example, the newspaper vendor might want to be 90 percent sure of not running out of newspapers each Sunday.

We described a normal distribution. If we assume that the distribution is normal and the newspaper vendor stocked exactly 100 papers each Sunday morning, the risk of stock running out would be 50 percent. The demand would be expected to be less than 100 newspapers 50 percent of the time, and greater than 100 the other 50 percent. To be 90 percent sure of not stocking out, he needs to carry a few more papers. From the "standard normal distribution", we know that we need to have additional papers to cover 1.282 standard deviations, in order to ensure that the newspaper vendor is 90 percent sure of not stocking out.

A quick way to find the exact number of standard deviations needed for a given probability of stocking out is provided by Microsoft Excel. Press 'insert' and you will find 'functions'. Click on 'function' and select the category 'statistical'. You can then use the NORMSINV (probability) function to get the answer. NORMSINV returns the inverse of the standard normal cumulative distribution. In this case, NORMSINV (.90) = 1.281552. This means that the number of extra newspapers required by the vendor would be 1.281552 × 10 = 12.81552, or 13 papers. This result is more accurate than what we can get from the tables and is sometimes very useful.

If we know the potential profit and loss associated with stocking either too many or too few papers on the stand, we can calculate the optimal stocking level using marginal analysis. The optimal stocking level occurs at the point where the expected benefits derived from carrying the next unit are less than the expected costs for that unit. This can be mathematically expressed as follows:

If C_o = Cost per unit of demand overestimated, and C_u = Cost per unit of demand overestimated and the probability that the unit will be sold is 'P'; the expected marginal cost equation can be represented as:

$$P\,(C_o) < (1 - P)C_u$$

Here (1-P) is the probability of the newspaper not being sold. Solving for P, we obtain

$$P < [C_u/(C_o + C_u)]$$

This equation states that we should continue to increase the size of the order so long as the probability of selling what we order is equal to or less than the Ratio $C_u/(C_o + C_u)$.

Single-period inventory models are useful for a wide variety of service and manufacturing applications.

11.2 Multiple Period Inventory Models

Multi-period inventory systems are designed to ensure that an item will be available on an ongoing basis throughout the year. There are two general types of systems and these inventory systems can be distinguished on the basis of the ordering criteria. The models of these two systems are; (a) Fixed-Order Quantity Models (also called the Economic Order Quantity models) and (b) Fixed-Time Period Models (also referred to as the Periodic System or P-models).

The basic difference between the two systems is that the fixed-order quantity models are "event triggered" and fixed time period models are "time triggered." In other words, at an identified level of the stock the fixed-order quantity model initiates an order. This event may take place at any time, depending on the demand for the items considered. In contrast, the fixed time period models review the stocks at time intervals that are fixed and orders are placed at the end of predetermined time periods. In these models, only the passage of time triggers action.

Notes

Notes Table makes a comparison of the two systems and brings out the significant differences.

Table: Fixed-order Quantity and Fixed-time Period Differences

Feature	Fixed-order quantity Model	Fixed-time Period Model
Order quantity	The same amount ordered each time	Quantity varies each time order is placed
When to place order	Reorder point when inventory position dips to a predetermined level	Reorder when the review period arrives
Record keeping	Each time a withdrawal or addition is made	Counted only at review period.
Size of inventory	Less than fixed-time period model	Larger than fixed-order quantity model
Time to maintain	Higher due to perpetual record keeping	
Type of items	Higher-priced, critical, or important items.	

The models that emanate from this system are for perpetual systems that require continual monitoring of inventory. Every time a withdrawal from inventory or an addition to inventory is made, records must be updated. Generally, the Fixed-Order Quantity models are favored when:

1. Items are more expensive items because average inventory is lower.
2. Items are critical, e.g., repair parts, because there is closer monitoring and therefore quicker response to potential stock out.

The models that emanate from this are similar to batch processing systems; counting takes place only at the review period. The Fixed-time Period models require a larger average inventory because it must also protect against stock out during the review period; while the fixed-order quantity mode has no review period.

These differences and the nature of operations tend to influence the choice of the inventory system that is more appropriate.

11.3 Fixed-order Quantity Modeling

In this unit we will consider Fixed-order Quantity i.e. inventory models in which demand is assumed to be fixed and completely predetermined. The heart of inventory analysis resides in the identification of relevant costs.

11.3.1 Uncertainty in Demand and Lead Time

Inventory systems have to cope with uncertainty. You have to decide on when to order and how much to order with a view minimization of costs, maximization of profit, or maximization of service level i.e. the objectives stated by the organization.

The most common way to estimate demand is to collect data about past experience and forecast future demand based on that data. However, in re-order point models the probability distribution of demand during the lead-time is an important characteristic in inventory management. There is also uncertainty in demand, in costs, in lead-time and in supplied quantity

It is often assumed that demand for an item is formed from a large number of smaller demands from individual customers. As a result, the resulting demand is continuous and follows a Normal

Notes

distribution. For fast moving items a Normal distribution is appropriate, especially for items with average lead-time demand higher than 10. Demand can then be measured using:

1. The average usage rate form historical data, and
2. The standard deviation of usage about the average.

Using the Normal distribution for a demand distribution can be questioned because:

1. The distribution is defined both on the positive and negative axes; and
2. It is symmetrical.

The demand may take on many shapes. While the Normal distribution could be approximately correct in many cases, it cannot be used in computer simulation if and when negative demand is generated, which may be generated at random. When of relevance, one should rather look for a distribution, which is defined only for non-negative values and allows for skewness.

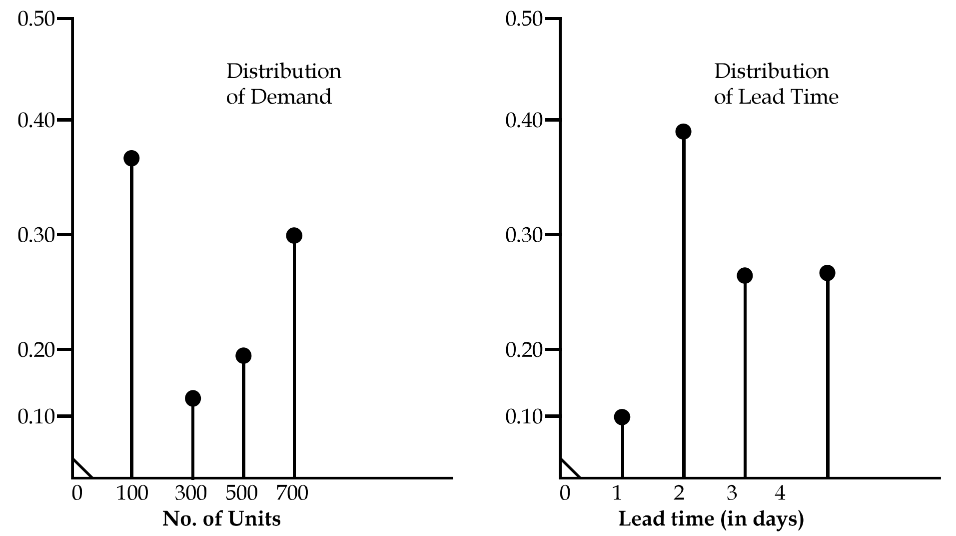
The Poisson distribution has been found to provide a reasonable fit when demand is very low (only a few pieces per year). Less attention has been paid to irregular demand. This type of demand is characterized by a high level of variability, but may be also of the intermittent type, i.e. demand peaks follow several periods of zero or low demands. In such a situation forecasting demand is considered difficult.

Example: Normal distribution describes many inventory situations in manufacturing; and the negative exponential and the Poisson describe many of the wholesale and retail level situations.

Some of the common forecasting methods used are simple exponential smoothing, and moving average method. These methods are used to cope with the uncertainty in demand, in costs, in lead-time and in supplied quantity.

The distribution may be normal, Poisson, negatively exponential distribution or any other form. Therefore, a simple way in which it becomes easier to identify the distribution is to use frequency distribution to identify the variability. To illustrate this approach, relative frequencies for demand and lead time of a hypothetical example are shown in Figure 11.1.

Figure 11.1: Relative Frequency Distribution of Demand and Lead Times



Since in most cases demand is probabilistic, in such cases policies are based on expected costs rather than actual costs. Expected costs are obtained by multiplying the actual costs for a particular occurrence with the probability of the occurrence of the event. This type of model is called the 'Christmas tree problem'.

In the cases of discrete probabilities, the manner in which frequency distributions can be used to decide on order quantities is explained with this example. Say, a television dealer finds that cost of holding a television in stock for a week is ₹30 and the cost of unit shortage is ₹70. For one particular model of television, the probability distribution of weekly sales is given in Table 11.1.

Table 11.1: Probability Distribution of Weekly Sales

Weekly sales	0	1	2	3	4	5	6
Probability	0.05	0.10	0.20	0.25	0.20	0.15	0.05

How many units per week should the dealer order?

The procedure to solve this problem is as follows:

Step 1: Determine the cumulative probabilities for the demand for the item 'D', such that the probability 'p' = D ≥ Q, i.e. probability of 'D' should be greater than or equal to 'Q'.

Step 2: Let C_h = holding cost per unit for the period and, C_b = under-ordering or shortage cost per unit for the period. Calculate the ratio, 'k', known as critical probability, such that $k = C_h/(C_h + C_b)$.

Step 3: Compare the cumulative probabilities with the critical probability 'k'. Identify the largest value of 'Q' for which the cumulative probability is equal to, or greater than, the critical probability value.

This will give the required ordering quantity. In general terms, the optimal ordering quantity, Q* is determined as:

$$Q^* = \text{Max. 'p' } (D \geq Q) > k$$

Where, $k = C_h/(C_h + C_b)$.

In our example the results are shown in Table 11.2. Comparing the cumulative probabilities with 'k', we find that the maximum value of 'Q' where 'p' (D ≥ Q) > k is '4'. In this example, the optimum policy is to stock 4 units. In case of continuous distributions, a similar method can also be used.

Table 11.2: Critical Probability and Order Quantity

Demand (in units)	**Prob. the demand will be at this level**	**Prob. That demand will be at this level or greater P(d>Q)**
1	0.15	1.00>0.30
1	0.10	0.95>0.30
2	0.10	0.85>0.30
3	0.25	0.65>0.30
4	0.20	0.40>0.30
5	0.15	0.20>0.30
6	0.05	0.05

A similar logic and approach can be used in the case when lead times are probabilistic. Such problem types are encountered more frequently for costly spare parts, perishable goods, seasonal items like in fashions and room heaters, air-conditioners etc.

11.3.2 Model with Specified Service Levels

Look closely at the data in Table 11.2, there are several relationships that can be imputed. One such is the service level. If we want to provide a 95 percent assurance of being able to meet customer demand until the new shipment is received, there is a cost involved. This will reflect in higher levels of average inventory than they otherwise would have been. This cost is critical and is optimized with the expected stock out costs.

The expected stock out cost, a key calculation in the total inventory cost, is the expected probability of a stock out times the stock out costs that are incurred regardless of the number of units short. The complementary cumulative function can also be used to set buffer stocks for the allowable number of stock outs per year. The expected number of stock outs for a demand level is found by multiplying the number of orders in a year (D/Q) times the probability of a stock out.

Task Prepare a study note on the inventory model with uncertainty in demand.

11.4 Summary

- It is often assumed that demand for an item is formed from a large number of smaller demands from individual customers. As a result, the resulting demand is continuous and follows a Normal distribution.
- Inventory systems have to cope with uncertainty. You have to decide on when to order and how much to order with a view minimization of costs, maximization of profit, or maximization of service level i.e. the objectives stated by the organization.
- The most common way to estimate demand is to collect data about past experience and forecast future demand based on that data.
- However, in re-order point models the probability distribution of demand during the lead-time is an important characteristic in inventory management.

11.5 Keywords

Christmas Tree Problem: This type of problem occurs where demand is probabilistic. In such cases policies are based on the probability of the occurrence of the particular event rather than actual costs.

Price-Break Models: When item cost varies with volume ordered, the result is a modified simple lot size situation called the quantity volume case or price break model.

11.6 Self Assessment

Fill in the blanks:

1. The .... occurs at the point where the expected benefits derived from carrying the next unit are less than the expected costs for that unit.
2. .... seek to optimize the costs associated with investing in an idle resource.
3. .... models are useful for a wide variety of service and manufacturing applications

Notes

4. .... systems are designed to ensure that an item will be available on an ongoing basis throughout the year
5. The basic difference between the two systems is that the fixed-order quantity models are "event triggered" and fixed time period models are ....
6. Fixed orders are placed at the end of .... time periods.
7. The most common way to estimate demand is to collect data about past experience and .... based on that data.
8. The .... has been found to provide a reasonable fit when demand is very low
9. The .... can also be used to set buffer stocks for the allowable number of stock outs per year.
10. The expected number of stock outs for a .... is found by multiplying the number of orders in a year (D/Q) times the probability of a stock out.

11.7 Review Questions

1. Define different types of inventory models.
2. Discuss uncertainty in demand and lead time.
3. What do you know about the Christmas Tree problem?
4. Illustrate the models with specified service levels.

Answers: Self Assessment

1.	Optimal stocking level	2.	Inventory models
3.	Single-period inventory	4.	Multi-period inventory
5.	"time triggered."	6.	Predetermined
7.	forecast future demand	8.	Poisson distribution
9.	complementary cumulative function	10.	demand level

11.8 Further Readings

Books

Jones, T.C., and Riley, D.W., 1985, *Using Inventory for Competitive Advantage through Supply Chain Management*, International Journal of Physical Distribution and Materials Management 19(8), 3-8.

Krajewski and Ritzman, *Operations Management, Strategy and Analysis*, Pearson Education, 2002.

Melnyk, S. and D. Denzler, *Operations Management: A Value Driven Approach*, McGraw-Hill, 1996.

Vonderembse, Mark, White, Gregory, *Operations Management, Concepts, Methods and Strategies*, John Wiley & Sons, 2004.

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Notes

Unit 12: Service Level Method of Determining Q – ABC Classification

CONTENTS

Objectives

After studying this unit, you will be able to:

- Describe various service level methods of determining quality
- Discuss the concept of ABC classification and analysis
- Explain the types of classification for the monitoring of the inventory

Introduction

ABC classification (ABC ranking) A method of ranking items held in inventory enabling particular attention to be given to those that, if incorrectly managed, will be most damaging to the effectiveness or the efficiency of an operation. Items are categorized according to their value of usage, i.e., their individual value multiplied by their usage rate. It is a classification based on Rupee usage of the inventory. The high value items, i.e., the first 20% are classified as 'A', the next 30% are classified as 'B' and the last 50% are classified as 'C' category items.

12.1 ABC Classification and Analysis

Vilfredo Pareto postulated the 80-20 rule; surprisingly, inventory also seems to follow that rule. In other words, typically only 20 percent of all the items account for 80 per cent of the total rupee usage, while the remaining 80 percent of the items typically account for remaining 20 percent of the rupee value. This truth leads to the ABC classification.

The ABC classification is based on focusing efforts where the payoff is highest; i.e., high-value, high-usage items must be tracked carefully and continuously. As these items constitute only 20 percent, the ABC analysis makes the task relatively easier.

After calculating the rupee usage for each inventory item, the items are ranked by rupee usage, from highest to lowest. The first 20 percent of the items are assigned to class 'A'. These are the items that warrant closest control and monitoring through a perpetual inventory system.

One of the major costs of inventory is annual carrying costs, and your money is invested largely in class 'A'. Tight control, sound operating doctrine, and attention to security on these items would allow you to control a large rupee volume with a reasonable amount of time and effort.

The next 30 percent of the items are classified as 'B' items. These deserve less attention than 'A' items. Finally, the last 50 percent of items are 'C' items. These have the lowest rupee usage and can be monitored loosely, with larger safety stocks maintained to avoid stock outs. They should have carefully established but routine controls.

Table 12.1: ABC Analysis of Chest of Drawers

Item stock number	Description	Annual Rupee usage	Percent of total Rupee usage	Cumulative Usage	ABC Classification
B 101	Sides	43600	19.96	19.96	'A'
H 107	Drawer sides	31000	15.61	37.57	'A'
F 105	Drawer front	25215	12.70	50.27	'A'
J 109	Drawer back	20020	10.08	60.35	'A'
A 100	Top	15000	7.55	67.91	'B'
G 106	Drawer front	13080	6.59	74.50	'B'
D 103	Frame rail	12075	6.08	80.58	'B'
M 112	Web frame end	11000	5.54	86.12	'B'
L 111	Web frame rail	7000	3.53	89.64	'C'
C 102	Frame rail	6250	3.15	92.79	'C'
I 108	Drawer sides	6000	3.02	95.81	'C'
E 104	Toe kick	4140	2.09	97.90	'C'
K 110	Drawer back	4000	2.01	99.91	'C'
N 113	Nails	80	0.04	99.95	'C'
O 114	Screws	55	0.03	99.98	'C'
P 115	Knobs	40	0.02	100.00	'C'
	Total	**198555.00**			

The 'chest of drawers' that we used as an example earlier has been used as an example here also. The ABC Analysis shows that in the16 items in the BOM, the first 20 percent have a rupee usage of 60.35 percent, the next thirty percent have a rupee usage of 25.77 percent, and the last 50 percent have a rupee usage value of only 13.88 percent. You can also see that only 4 items fall in the 'A' category, 4 items in the 'B' category, and the remaining 8 items fall in the 'C' category. Though, the example does not show the 80-20 rule because this is a made-up example, it does indicate a trend towards the 80-20 rule.

This classification is commonly used by companies, as very often they need not keep extremely accurate track of all inventory items. For instance, high-value, high-usage items must be tracked carefully and continuously but certain parts with a relatively low value or infrequent use can be monitored loosely.

Controls for Class 'A' Items: All Class 'A' items require close control. However, where stock out costs are high, special attention is required. Raw materials that are used continuously, in extremely high volume, are often purchased at rates that match usage rates. Contracts are often executed with vendors, with penalty clauses, for the continuous supply of these materials. Buffer stocks that provide excellent service levels are justified for such items.

Where purchase of inventory items is not guided by either economical quantities or cycles, the items need careful monitoring. It is possible to achieve significant savings by changing the rate of flow periodically as demand and inventory positions change. Minimum supplies need to be ensured to guard against demand fluctuations and possible interruptions of supply.

For the balance of Class 'A' items, normally reports are generated on a weekly basis, to provide the necessary close surveillance over inventory levels. Close surveillance reduces the risk of a prolonged stock out. Depending upon the inventory system used, time triggered or event triggered orders are released.

Notes

Control for Class 'B' Items: These items are generally monitored and controlled by a computer-based exception reporting system. Periodic review by the management is necessary, but model parameters are reviewed less often than with Class A items. Normally, stock out costs for Class B items should be moderate to low, and buffer stocks should provide adequate control for stock outs, even though the ordering may occur less often.

However, for items that are scarce, lead time analysis and purchasing strategies can be critical. This is also true for a number of items that may have to be imported and in addition to normal transportation times, time required for clearance through customs may not be highly predictable.

Controls for Class 'C' items: Class C items account for the bulk of inventory items. In many cases, reorder point system is designed in such a way that it does not require a physical stock evaluation, for example using a "two-bin" system. The inventory is physically separated into two bins one of which contains an amount equal to the reorder inventory level. Stock is drawn from the second bin. For each item, action is triggered when the bin gets empty.

Routine controls adequately cover the requirements for this class of inventory. Semiannual or annual review of the system parameters should be performed to update usage rates, reestablish supply lead times, and the reorder points. Cost savings might result in changes in EOQ, but they may not be significant.

12.2 Other Classification Systems

Material items are classified based upon their commercial importance, demand patterns (regular, sporadic etc.) and supply reliability (of both raw material suppliers and own manufacturing), etc.

Most of these systems operate in a similar manner to the ABC Classification. A brief description and comparison of these classifications are given in Table 12.2.

Notes

Table 12.2: Comparison of Different Classification Systems

S. No.	Title	Basis	Main Uses
1.	ABC (Level of Usage)	Value of consumption	To control raw material components and work-in progress inventories in the normal course of business
2.	HML (High, medium, low usage)	Unit price of the material	Mainly to control purchase.
3.	FSND (Fast moving, Slow moving, Non-moving, Dead items)	Consumption pattern of the component	To control obsolescence.
4.	SDE (Scarce, difficult, easy to obtain items)	Problems faced in procurement	Lead time analysis and purchasing strategies
5.	Golf (Government, Ordinary, Local, Foreign Sources)	Source of the material	Procurement strategies
6.	VED (Vital, Essential, Desirable)	Criticality of the component	To determine the stocking levels of spare parts.
7.	SOS (Seasonal, Off-seasonal)	Nature of suppliers	Procurement/ holding strategies for seasonal items like agriculture products
8.	XYZ (Value of Stock)	Value of items in storage	To review the inventories and their use scheduled intervals.

Notes

Other similar types of classifications are the XYZ Classification, VED Classification, and the HML classification of inventory. The basic difference between the ABC Classification and the XYZ Classification is that it is based on the inventory in stock rather than usage.

The VED Classification is based on the criticality of the inventory item. In normal practice, items in the 'V' category are often monitored manually; in addition to the computer monitoring that may be in place. The HML reflects a classification based on the unit price of the item. Obviously, the 'H' category items require additional attention, especially if the lead times are long, as it may often be in imported components. The 'time' triggered reorder system has some advantages in production cycling, in such high value items.

All these techniques are used to focus management attention in deciding on the degree of control necessary for different items in the inventory. However, it should be kept in mind that changes in the business environment, e.g., customer demand patterns or material costs, can cause material item classifications to change. This, in turn, can affect key 'planning & scheduling' decisions.

Task Prepare a study note on the concept and usefulness of ABC classification.

12.3 Summary

- In most cases Pareto's Rule then applies, so that approximately 20% of the items accounts for approximately 80% of the value of the stock held; these items are classified as Class A items. Class B covers the 30% of items that represent the next 10% of value. Class C covers the remaining 50%, which accounts for the remaining 10% of value.
- In material requirements planning (MRP), ranking is used to categorize inventory by its impact value, i.e. whether or not production will stop if this item is out of stock.
- The VED Classification is based on the criticality of the inventory item. In normal practice, items in the 'V' category are often monitored manually; in addition to the computer monitoring that may be in place.

12.4 Keywords

ABC Classification: The ABC classification is based on focusing efforts where the payoff is highest; i.e., high-value, high-usage items must be tracked carefully and continuously.

HML: The HML reflects a classification based on the unit price of the item.

VED Classification: The VED Classification is based on the criticality of the inventory item. In normal practice, items in the 'V' category are often monitored manually; in addition to the computer monitoring that may be in place.

12.5 Self Assessment

Fill in the blanks:

1. .... postulated the 80-20 rule.
2. The .... is based on focusing efforts where the payoff is highest
3. Tight control, sound operating doctrine, and attention to security on these items would allow you to control a .... with a reasonable amount of time and effort.

Notes

4. .... are often executed with vendors, with penalty clauses, for the continuous supply of these materials.
5. .... that provide excellent service levels are justified for A class items.
6. .... costs for Class B items should be moderate to low, and buffer stocks should provide adequate control for stock outs, even though the ordering may occur less often.
7. .... items account for the bulk of inventory items.
8. All Class 'A' items require .... control.
9. Material items are classified based upon their ...., demand patterns and supply reliability etc.
10. The .... is based on the criticality of the inventory item

12.6 Review Questions

1. Discuss the concept of ABC classification.
2. What do you understand by ABC Analysis of Chest of Drawers?
3. What are the other types of classification used in the monitoring of inventory?

Answers: Self Assessment

1.	Vilfredo Pareto	2.	ABC classification
3.	large rupee volume	4.	Contracts
5.	Buffer stocks	6.	Stock out
7.	Class C	8.	Close
9.	Commercial importance	10.	VED Classification

12.7 Further Readings

Books

Jones, T.C., and Riley, D.W., 1985, *Using Inventory for Competitive Advantage through Supply Chain Management*, International Journal of Physical Distribution and Materials Management 19(8), 3-8.

Krajewski and Ritzman, *Operations Management, Strategy and Analysis*, Pearson Education, 2002.

Melnyk, S. and D. Denzler, *Operations Management: A Value Driven Approach*, McGraw-Hill, 1996.

Vonderembse, Mark, White, Gregory, Operations Management, Concepts, Methods and Strategies, John Wiley & Sons, 2004.

Unit 13: Supply Chain Management and JIT

CONTENTS

Objectives

After studying this unit, you will be able to:

- Discuss benefit and need for supply chain management
- Explain elements of supply chain management
- Define logistics
- Understand EDI

Notes

- Explain e-commerce
- Discuss requirements for supply chain management
- Explain performance optimization
- Describe JIT and Lean operations
- Discuss JIT in services

Introduction

Supply chain management encompasses both physical distribution and supply management. Supply or material management activities focus on the upstream portion of the supply chain and are mainly concerned with suppliers and inbound logistics. Physical distribution activities involve that part of the supply chain where work-in-process becomes finished goods and moves toward customers. Understanding the relationships between the terms is important to being able to conceptualize a holistic supply chain.

This change was driven by a number of macro level forces: an empowered consumer; a shift in economic power toward the end of the supply chain; deregulation of key industries; globalization; and technology, especially the phenomenal developments in data processing and communication technologies. These forces elevated the importance of supply chain management as a strategic weapon for competitive advantage.

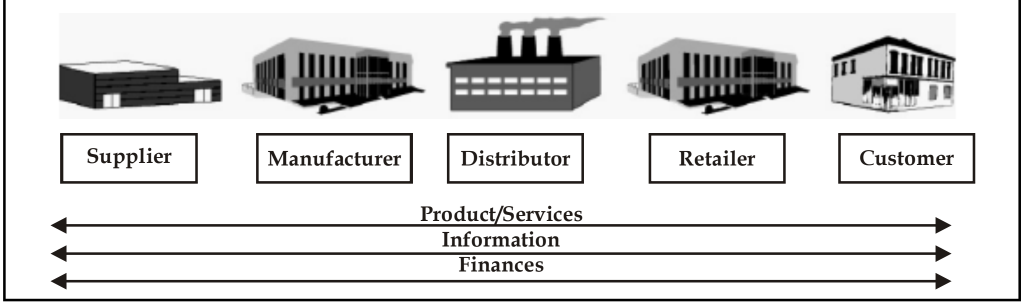
The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves. In this unit, we will discuss the supply chain. Despite its importance, inventory is not universally well understood. It is variously characterized, both positively and negatively, as an economic asset to a non-income-producing use of capital funds. We will also discuss about Just-in-Time concept, and its relevance in services.

13.1 Benefits and Need for Supply Chain Management

'Supply Chain Management' is defined as the integration-oriented skills required for providing competitive advantage to the organization that are basis for successful supply chains. A typical supply chain may involve a variety of stages. These supply chain stages include:

1. Customers
2. Retailers
3. Wholesalers/Distributors
4. Manufacturers
5. Component/Raw material suppliers

Figure 13.1: The Supply Chain



The concept of a supply chain is shown in Figure 13.1. Though many stages are shown in the figure, each stage need not be present in a supply chain. The number of stages included should meet the primary purpose for the existence of the supply chain, i.e., to satisfy customer needs. It is in the process that the organization generates profits for itself.

'Supply Chain Management' can be defined as the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. It represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective and efficient ways possible.

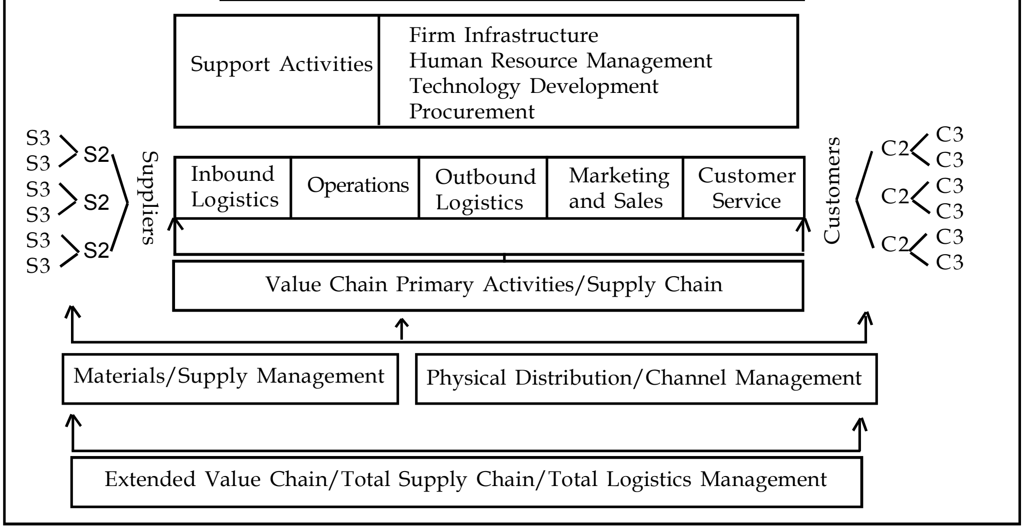
Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. The functions that are involved include but are not limited to, new product development, marketing, operations, distribution, finance, and customer service. The decisions are trade off between price, inventory, and responsiveness.

Its activities begin with a customer order and ends when a satisfied customer has paid for his or her purchase. Generally, more than one player is involved at each stage. A manufacturer may receive materials from several suppliers and then supply several distributors. Thus, most supply chains are actually networks.

Supply chain is an integral part of the value chain. According to Michael Porter, who first articulated the value chain concept in the 1980s, the value chain is comprised of both the primary and support activities. The supply chain consists only of the primary activities or the operational part of the value chain. The supply chain, therefore, can be thought of as a subset of the value chain. In other words, while everyone in the same organization works in the value chain, not everyone within the organization works in the supply chain.

The value a supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer's request. The supply chain profitability is based on the effort involved in the appropriate management of the flows between and among stages in a supply chain. Unlike the traditional measure of organizational success in terms of the profits at an individual stage, supply chain success is measured in terms of supply chain profitability.

Figure 13.2: Supply Chain is Part of the Value Chain



The objective of every supply chain is to maximize the overall value generated so that the final price of the good covers all of the costs involved plus a profit for each participant in the chain. Figure 13.2 shows the supply chain as a network and also as a part of the value chain.

The appropriate design of the supply chain will depend on both the customer's needs and the role of the stages involved. In some cases, a manufacturer may fill customer orders directly.

Example: Dell has been one of the most successful examples of effective supply chain management. Dell builds-to-order, that is, a customer order initiates manufacturing at Dell. Dell does not have a retailer, wholesaler, or distributor in its supply chain. While other computer companies must stock a month of inventory, Dell carries only a few days worth. In fact, many of the components are delivered within hours of being assembled and shipped to the customer. It plans orders and signals suppliers every two hours, which enables it to manufacture and deliver exactly what its customers want.

In other cases, such as in a mail order business like Amazon.com, the company maintains an inventory of product from which they fill customer orders. In the case of retail stores, the supply chain may also contain a wholesaler or distributor between the store and the manufacturer.

13.2 Elements of Supply Chain Management

The major elements in Supply Chain are:

1. ***Production:*** Strategic decisions regarding production focus on what customers want and the market demands. This first stage in developing supply chain agility takes into consideration what and how many products to produce, and what, if any, parts or components should be produced at which plants or outsourced to capable suppliers. These strategic decisions regarding production must also focus on capacity, quality and volume of goods, keeping in mind that customer demand and satisfaction must be met. Operational decisions, on the other hand, focus on scheduling workloads, maintenance of equipment and meeting immediate client/market demands. Quality control and workload balancing are issues which need to be considered when making these decisions.

2. ***Inventory:*** Further strategic decisions focus on inventory and how much product should be in-house. A delicate balance exists between too much inventory, which can cost anywhere between 20 and 40 percent of their value, and not enough inventory to meet market demands. This is a critical issue in effective supply chain management. Operational inventory decisions revolved around optimal levels of stock at each location to ensure customer satisfaction as the market demands fluctuate. Control policies must be looked at to determine correct levels of supplies at order and reorder points. These levels are critical to the day to day operation of organizations and to keep customer satisfaction levels high.

3. ***Location:*** Location decisions depend on market demands and determination of customer satisfaction. Strategic decisions must focus on the placement of production plants, distribution and stocking facilities, and placing them in prime locations to the market served. Once customer markets are determined, long-term commitment must be made to locate production and stocking facilities as close to the consumer as is practical. In industries where components are lightweight and market driven, facilities should be located close to the end-user. In heavier industries, careful consideration must be made to determine where plants should be located so as to be close to the raw material source. Decisions concerning location should also take into consideration tax and tariff issues, especially in inter-state and worldwide distribution.

4. ***Transportation:*** Strategic transportation decisions are closely related to inventory decisions as well as meeting customer demands. Using air transport obviously gets the product out quicker and to the customer expediently, but the costs are high as opposed to shipping by boat or rail. Yet using sea or rail often times means having higher levels of inventory in-

house to meet quick demands by the customer. It is wise to keep in mind that since 30% of the cost of a product is encompassed by transportation, using the correct transport mode is a critical strategic decision. Above all, customer service levels must be met, and this often times determines the mode of transport used. Often times this may be an operational decision, but strategically, an organization must have transport modes in place to ensure a smooth distribution of goods.

5. ***Supply:*** An organization must determine what their facility or facilities are able to produce, both economically and efficiently, while keeping the quality high. But most companies cannot provide excellent performance with the manufacture of all components. Outsourcing is an excellent alternative to be considered for those products and components that cannot be produced effectively by an organization's facilities. Companies must carefully select suppliers for raw materials. When choosing a supplier, focus should be on developing velocity, quality and flexibility while at the same time reducing costs or maintaining low cost levels. In short, strategic decisions should be made to determine the core capabilities of a facility and outsourcing partnerships should grow from these decisions.

6. ***Information:*** Effective supply chain management requires obtaining information from the point of end-use, and linking information resources throughout the chain for speed of exchange. Overwhelming paper flow and disparate computer systems are unacceptable in today's competitive world. Fostering innovation requires good organization of information. Linking computers through networks and the internet, and streamlining the information flow, consolidates knowledge and facilitates velocity of products. Account management software, product configurations, enterprise resource planning systems, and global communications are key components of effective supply chain management strategy.

13.3 Logistics

Logistics focuses on the physical movement and storage of goods and materials. This involves evaluating and selecting various transportation options, developing and managing networks of warehouses when needed, and managing the physical flow of materials into and out of the organization.

These physical flows are often called in-bound and out-bound logistics, respectively. In-bound logistics is the movement of materials from suppliers and vendors into production processes or storage facilities. Outbound logistics is the process related to the movement and storage of products from the end of the production line to the end user.

Logistics decisions are often tightly intertwined with production and inventory decisions, particularly when businesses must decide where to hold inventory in the supply chain. In some cases, logistics help decide on the appropriate type of packaging for products. Logistics personnel also must work closely with marketing to determine the channels (e.g., wholesalers, retailers, and mail-order) by which to distribute the firm's products and services. Material and products can also flow back up the supply chain. For example, customers might need to return damaged or outdated products. This process is called reverse logistics. An important new trend is the recovery and recycling of products after they have reached the end of their useful lives.

There is a new trend due to the increasing concern for the environment where supply chains often extend beyond the final customer to include the acceptance and "disassembly" of final products for re-use in new products. In this sense, this is an attempt by organizations to "close the loop", so that they can avoid harming the environment. With increasing demand for this type of service, reverse logistics presents a different set of logistics challenges that organizations have to meet in the future.

Notes

13.3.1 In-bound Logistics: Stores, Material Handling and Receiving

A critical part in supply chains that involve manufacturing is getting all the required parts and raw materials in the right sequence, the right quantity, the right quality and the right time to the manufacturing and assembly plants. Transportation and warehousing are a big part of most inbound logistics chains. In large manufacturing units, these are often very complex activities.

Inbound logistics is one of the most neglected segments of the supply chain. Supply chain organizations are generally focused on managing outbound logistics, and marketing departments have identified different logistics requirements for the finished goods segment. Similarly, purchase departments have a set of requirements for inbound raw materials, etc.

With the common adaptation of just-in-time (JIT) manufacturing methods, it pushes managers to aim for achieving lowest inventory models, often at the expense of higher inbound transportation costs. It is this inherent conflict in balancing JIT manufacturing practices with inbound logistics and transportation needs that manufacturing or retail organizations need to address.

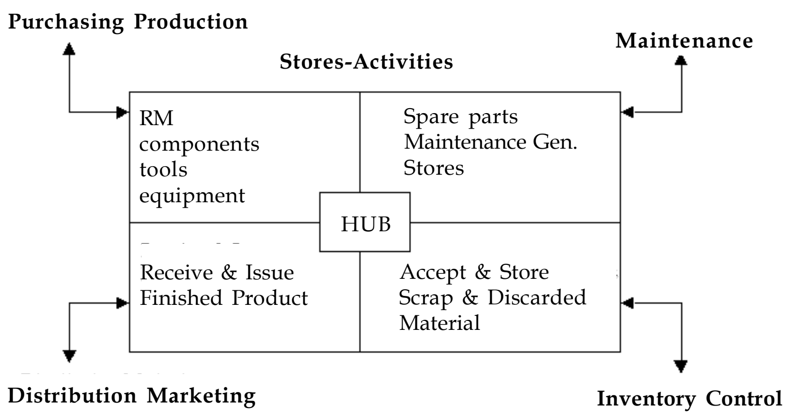
Stores

An organization usually has different types of stores such as Raw Materials Store, Processed or Semi-Finished Materials Store, Finished Goods Store, Yard Store and so on. Storage is an essential and most vital part of the economic cycle and Storage Management is a specialized function, which can contribute significantly to the overall efficiency and effectiveness of the materials function.

The art of storekeeping is largely that of optimizing the use of resources to meet actual needs in an efficient manner. Stock taking is an integral part of Stores function. Efficiency of Stores function is measured by the number of times the stocks have turned over. That is how much time material spends in the Warehouse.

The lesser time the stock spends, the better is the efficiency of the stores function. Money is a scarce resource and once it is converted into materials, it is useful only when the materials have reconverted back into money. This is the essence of stock turnover. It is an indication of the agility of an organization.

Figure 13.3: Schematic of Stores Activities



A schematic diagram of stores activities is given in Figure 13.3. Service being the most important objective of Stores it is obviously desirable to provide that service in the most economical manner. Usually Stores Managers in the past were more concerned about the service levels than other considerations resulting in a pile-up of inventory that would neither move fast nor can be thrown out. The search is for the most cost-effective solutions to organize and reduce inventory levels.

Agility has now become a very important requirement in Organizations. The solution is being found in technological advances that provide visibility in the whereabouts of all parts moving to the plant at any given time. Agility and sprightliness of Stores Function is based on these types of technological advances. These contribute substantially in making the whole organization flexible as is the need of the hour. Customer demands have become very aggressive and organizations need to react, respond and immediately satisfy them in order to remain in the customer's good books and get repeat orders.

Stores is a very broad word that indicates a wide variety of materials stored such as chemical, metals, liquids, gases, spare parts, equipment, or finished goods, ranging from engineering components to drugs and pharmaceuticals.

Each of these items will require a specific type of storage and their handling and preservation methods will vary accordingly. There is a high degree of specialization required to store and handle these products and in many cases special storage licenses need to be obtained from the Government, e.g., the storage of petroleum products or explosive products. It is hence mandatory for Stores personnel to understand thoroughly all of these requirements and implications.

Stores range from ordinary ones with shelves and bins to cold or dehumidified storages, huge silos for storage of food grains or bonded warehouses for keeping goods on which customs and excise duties have not been paid. The number of different storage devices is almost as large as the number of different materials.

One key to selecting a storage device is the accessibility of the material. Another key relates to its ability to utilize vertical and horizontal space efficiently. The following storage devices are common:

1. For bulk storage of products, large bins with chutes that can easily feed materials to a process are often used. Other bulk products may be stored in drums or other large containers. Products stored in bulk are usually commodity items that do not have an individual part identity. Some examples are iron ore for steel making, stone for paving roads and parking lots, alumina for making aluminium, and chemicals for making paper.

2. Pallet is the base over which the load of material is assembled. Pallets are specially designed platforms, which may be lifted by fork-lifts.

3. Pallet racks are devices that can be used to stack pallets on top of one another. A pallet is a storage platform, usually made of wood that a fork-lift can easily pick up. Pallets facilitate quick movement of batch production items or parts from one point in a facility to another.

4. Intelligent warehouse systems use Drive-in racks: computer controls guide driverless vehicles to the proper rack. Drive-in racks allow forklifts to drive between the racks, which are in vertical columns. Forklifts can drive in and pull material from any point in the rack and drive out again to deliver it.

5. Flow-through racks is another new introduction. These racks tend to be used for smaller products that move in and out of inventory quickly. In flow-through racks, the racks are rollers and the shelves are tilted in one direction. Materials are added at the back of the shelves and roll down to the front, where they are removed.

6. Bin racks are used for storing smaller parts. Bins may have special dividers, spacers, or containers for keeping parts from mixing together.

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7. Automated Storage and Retrieval System (AS/RS) are storage rack systems in which each location and its inventory status is maintained by a computer-controlled central unit. When a certain item is needed, a computer, using its status file, locates the item on the shelf. To retrieve the part, a driverless device, such as an AGV, automatically picks up the item. In case of new items, the location of the rack where it is to be stored is communicated by the computer to the lifting device. Subsequently, the inventory status is updated.

Material Handling Equipment

Material handling is an important part of managing materials. How will the material be moved? Physically moving material requires equipment of various kinds, depending on the type and amount of material to be moved.

Cost-efficient material handling is an important issue.

Did u know? Material movement usually accounts for about 25% of total factory cost, therefore, a careful study of alternative modes of material transportation are very important.

There are some guiding principles of material handling. These are:

1. Reduce unnecessary movement by selecting the shortest path to reach the destination.
2. Reduce congestion and bottlenecks by eliminating obstruction and congestions in the material handling.
3. Use scientific factory layout to minimize the overall material movement and reduce the number of trips. This will result in reduced transportation costs.
4. Use of standard material handling equipments to facilitate easy maintenance and availability of spares.
5. Minimize handling as it reduces the chances of breakage. It also reduces loading/unloading time and cost.
6. Use gravity to transport material, wherever possible.
7. Use mechanized material handling equipment to reduce dependence on human labour.

The attempt in material handling is to use flexible equipments wherever possible and specialized equipment, only if necessary. The equipment should be simple and safe with operator safety as the prime objective. Listed below are a few material-handling devices and when they might be used.

1. ***Overhead Cranes and Hoists:*** Overhead cranes and hoists are used to move heavy objects through a plant. They are used for the movement of material in a fixed route and fixed area of operation. They come in a variety of sizes, and many are able to lift twenty-five tons or more. Moving steel slabs is an example of an overhead crane application. Overhead cranes are efficient at moving small parts only if the parts can be put together in a large batch and moved in one trip.
2. ***Conveyors:*** Conveyors are used to transport material from one fixed point to another fixed point. Some conveyors have belts that can move parts or granular material; others have a series of hooks that can move parts through a paint system. Some use gravity or a powered device to carry material. Some of the conveyor systems are portable which may be moved from time to time, but generally these are fixed. These are used for the following applications:
    (a) Moving homogeneous material

(b) Fixed route of movement

(c) Constant rate of material movement

(d) Mass production units

3. ***Industrial Trucks:*** These are manual or external powered vehicles, which can move on a variety of paths. These are particularly useful for the following situations:

   (a) Uneven (intermittent) supply of material

   (b) Varying paths of movement

   (c) Job-shop production units

4. ***Forklifts:*** Forklifts are used to move parts through varying paths. Because they have drivers, these vehicles are very flexible. Forklifts generally do not move large volumes of parts along the same path.

5. ***Automated Guided Vehicles (AGVs):*** AGV is a programmed vehicle, used to carry load from one location to another in an automated work place. They can be used to move parts through a variety of paths and are flexible in that they can be directed to follow more than one path. The most common type of such vehicles normally follows a predetermined path on floor embedded wires arranged to form closed loops. These vehicles are called as wire guided AGVs.

   Another variety is free-ranging AGVs, which offer more flexibility, as they need not move on a pre-specified path. An off-board controller is used to send despatcher commands for the identification of the load, destination of the load and, other instructions related to loading and unloading of the load.

6. ***Elevators and Lifts:*** These are used to raise or lower material in the vertical direction. They are just like lifts of a multi-storied building but carry material.

Efficient planning and control of the material handling system can add to efficiency.

Example: Standard size of material should be transported to reduce time. Part orientation principle should be employed so that, while unloading, the material position should be as per the need of the destination point.

By using the concept of unit size load, many companies aggregate material into a longer unit/ container or pallet of standard size thereby saving on transportation costs. Backtracking of parts movement should be avoided as it only adds to cost and time. Cost-efficient material handling is beneficial to both the organization as well as the work force.

Receiving

Receiving is a follow-on activity to a purchase order. It forms the basis for updating the financials and inventory records and can trigger warehouse management and the quality management processes. Traditionally, receiving and inspection share facilities. As soon as material is received, it is documented and passed on to quality control for inspection and then moved to stores for inward distribution to manufacturing.

For planning and controlling operations, accurate information regarding materials must be available. Information regarding description of all the materials, quantity received and their locations is entered into the organization's information system in receiving. With the warehouse management systems, you can control the goods receipt and goods issue processes at a physical level.

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Goods receipts are possible from purchase order, inbound deliveries (advanced shipping notice), stock transport orders, or from production orders. Advanced Shipping Notification is a vendor document that contains the exact materials, quantities, and the delivery date with reference to a purchase order. This document becomes the Inbound Delivery in the receipt process.

Notes The importance of receiving is reflected by Tata Steel who are spending ₹ 60-70 crores to upgrade their various facilities. Tata Steel's Jamshedpur plant handles about 13 million tonnes of raw materials per annum. Following capacity expansion, the raw material requirement will jump to 25 million tonnes annually by 2007-08. That means Tata Steel will have to handle 250,000 tonnes of material per day. Keeping in view the projected increased volume of raw materials it will have to handle, Tata Steel is taking steps to improve its infrastructure. The introduction of the engine-on-load system within the plant is being introduced to halve the unloading time of an iron ore rake which presently takes from eight to nine hours. The coal unloading system is being revamped, and with it the tipping capacity, so that rakes unloading time is halved to 12 hours or so.

The role of receiving has changed in SCM. In this context, receiving has as its objective the rapid flow of material into a facility. Ideally, the material would move directly to the production line without making an intermediate stop in a warehouse or other storage area. However, if the material cannot be used immediately, it is placed in storage.

Inventory Costing Methods

One of the most common methods is the "FIFO", or first in, first out, method. The oldest materials are considered to be issued first even through in a given instance the actual issue may be from the latest received lot of the given materials.

A second derived cost method is the so-called "LIFO", or last in, first out, method. This reverses the first in, first out method of pricing issues and new balances. Issues are assumed to come from the last received lot of materials so issues are priced at the cost of the latest shipment received.

A third method is the so-called "normal cost" method. This is used more, perhaps, for issuing company-fabricated parts than for issuing raw material or purchased part. It assumes as the cost for issue purposes the expected average price for the materials or part. Scientifically determined standard costs also are often used.

The fourth commonly used derived cost method for pricing issues of materials and parts in a factory is the average cost method. After each receipt of materials or parts, their cost is added to the cost of the units already on hand and the sum is divided by the total number of units on hand. This establishes an average cost per unit in stores. This average unit price is then used for all issues and for calculating new balances.

Task Analyse the inbound logistics system of Dabur India.

13.3.2 Out-bound Logistics: Distribution and Shipping

Once goods are produced, they need to go to the final customer. That is an obvious statement. What is less obvious, however, is how to get them there in the most cost effective manner while satisfying the ever increasing expectations on service levels and availability. This is the role of the distribution system and shipping.

The Distribution System

The distribution system is the physical link between suppliers and customers. In a complex production environment, which is typical of most developed countries, distribution systems link a series of suppliers and customers into a production chain. It ties the various stages of production into the production chain. Very few companies are completely vertically integrated; generally, several companies participate in building a complex product before it is delivered to the customer.

The distribution system is the interface between marketing and operations. It controls the actual fulfillment of sales orders and purchase orders as well as stock transport orders. In consumer product markets, a volatile consumer demand situation and increasing pressures on order cycle times and higher service levels are becoming important.

Demand and supply planning capabilities enable companies to maximize return on assets, and to ensure a profitable match of supply and demand. Responsiveness to demand changes and flexibility in planning are a must. Many companies obtain customer data from the retailer and immediately incorporate it into the planning data, thus providing up-to-date demand and supply situations.

Distribution systems have also been used to store large amounts of materials for rapid delivery to a customer to buffer inflexible production systems that were incapable of making the swift adjustments required to keep pace with rapidly changing customer needs.

The distribution system can have several distinct levels. Inventory may be maintained for distribution to customers in any of the levels:

1. The supplier's facility
2. In transit
3. A regional warehouse
4. A distribution center
5. The customer's facility

A distribution center serves a large number of customers and is planned on a regional basis or on the basis of customers. Regional warehouses often hold the bulk of the inventory in the distribution system because small inventories in several distribution centers would be more difficult to control and replenish. Often, distribution centers also act as order-taking and order-processing centers.

Each center maintains a limited inventory of high-demand items, which are frequently replenished from larger stocks at the regional warehouse. Small orders may be shipped to the distribution center, along with items ordered by other customers. These shipments will be broken down at the distribution center and shipped with orders for other customers.

Large orders received by a distribution center may be shipped directly from the regional warehouse or the supplier's facility to the customer's facility. Very often, in the case of large industrial purchases, stocks are held by second tier suppliers in local warehouses and are shipped on the basis of demand.

Shipping

Shipping is the beginning of the delivery system that sends the product ordered to the customer. It is a link to the outbound logistics and is a part of the distribution system which links suppliers and customers. The execution of logistics tasks begins with delivery processing; the goods are

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shipped and relevant details are documented. The outbound delivery forms the basis for goods issue posting.

The data required for goods issue posting is copied from the outbound delivery into the goods issue document so that:

1. Warehouse stock is reduced by the delivery quantity.
2. Value changes are posted to the balance sheet account in inventory accounting.
3. Requirements are reduced by the delivery quantity.
4. The serial number status is updated.
5. The goods issue posting is automatically recorded in the document flow.
6. Stock determination is executed for the vendor's consignment stock.
7. A work list for the proof of delivery is generated.

After goods issue is posted for an outbound delivery, the delivery might be shipped to the customer directly from the fulfilling locations (more than one delivery), or consolidation may occur at one location before one complete shipment is transported to the end customer.

Proof of Delivery (POD) is an instrument involved in business processes in which an invoice is issued only after the customer has confirmed the delivery's arrival. This is especially important for deliveries where the delivery quantity varies because of the nature of the goods or for which the exact delivery quantity is unknown from the start.

The reasons for deviation that occur most frequently in real-world scenarios are stock shrinkage, theft, certain characteristics of goods (volatility, for example), and transportation damage. These are recorded and analyzed in the system. This analysis is especially valuable when you are negotiating with forwarding agents, vendors, or customers, since all deviations can be reflected.

The role and nature of transportation is changing, companies are finding that responsive, cost efficient, door-to-door service often involves using more than one mode of transportation. They are increasingly searching for solutions of using different modes of transport in such a way that all the parts of the transportation process, including information exchange, are efficiently connected and coordinated. This has brought about a mushrooming of logistics companies that warehouse and act as 'middlemen' to distribute products of more than one company.

Figure 13.4: Transportation Modes and their Economics

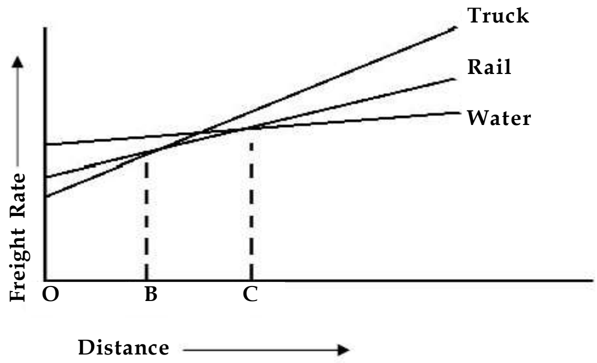

Figure 8.4 depicts the hypothetical transport costs profile for freight by mode type and distance. Point B is the actual distance at which average rail ton-kilometer costs become lower than

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average truck costs. At C, the average waterway ton-kilometer costs become lower than rail costs. Transport by truck in the short haul is cheapest with low fixed cost relative to the operating cost, while waterway transport is cheapest in the long haul with high fixed costs and low operating cost. For intra-city transport small transport units are most economical. There are a host of options, depending on the volume and weight of the shipment.

13.4 Electronic Data Interchange (EDI)

EDI (Electronic Data Interchange) is a standard format for exchanging business data.

Electronic data interchange (EDI) is the electronic exchange of business information – purchase orders, invoices, bills of lading, inventory data and various types of confirmations – between organizations or trading partners in standardized formats. EDI also is used within individual organizations to transfer data between different divisions or departments, including finance, purchasing and shipping. When the focus of EDI centers on payments, especially between banks and companies, the term financial EDI (FEDI) is sometimes used. Along with digital currency, electronic catalogs, intranets and extranets, EDI is a major cornerstone of e-commerce overall.

Two characteristics set EDI apart from other ways of exchanging information. First, EDI only involves business-to-business transactions; individual consumers do not directly use EDI to purchase goods or services. Secondly, EDI involves transactions between computers or databases, not individuals. Therefore, individuals sending e-mail messages or sharing files over a network does not constitute EDI.

While the concept of e-commerce did not receive widespread attention until the 1990s, large companies have been using EDI since the 1960s. The railroad industry was among the first to adopt EDI, followed by other players in the transportation industry. By the early 1980s, EDI was being used by companies in many different industry sectors. In the beginning, companies using EDI transferred information to one another on magnetic tape via mail or courier, which had many drawbacks including long lead times and the potential for a tape to be damaged in transit. During the 1980s, telecommunications emerged as the preferred vehicle for transferring information via EDI.

By the new millennium, EDI was used widely in many industries including manufacturing, finance, and retail. Some large retailers, among them Sears and Target, required suppliers to use EDI in order to engage in business transactions with them. Additionally, the Federal Acquisition Streamlining Act of 1994 (FASA) required all agencies within the United States government to use EDI.

Communication Methods

After identifying trading partners, entering into TPAs with them and purchasing the necessary hardware and software, a means of communication must be chosen. EDI can occur point-to-point, where organizations communicate directly with one another over a private network; via the Internet (also known as open EDI); and most commonly, via value-added networks (VANs) provided by third-party value-added-network services.

VANs are networks dedicated exclusively to EDI. Not only do they function like telephone lines by allowing for the transfer of information, they also contain storage areas, similar to e-mail boxes, where data sent from one party can be held until it is scheduled to be delivered to the receiver. VANs are able to provide translation services to small organizations that find it too cost prohibitive to do in-house with their own software. Companies may need to join more than one VAN because their partners belong to more than one. However, by the early 2000s most VANS were able to communicate with one another.

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In addition to translation, VANs offer a wide variety of other services including data backup, report generation, technical support, training, and the issuance of warnings if data is not properly transmitted between parties. Depending on need, all of the services offered by a VAN may not be required by a particular company. VANs vary in the way they charge companies. Some charge high implementation or setup fees followed by low monthly usage fees, or vice versa. Charges often are made based on the number of documents or characters involved in a given transmission. In the early 2000s, although many companies still relied on VANs, the Internet was playing a larger role in EDI. It is possible for companies to translate EDI files and send them to another company's computer system over the Internet, via e-mail or File Transfer Protocol (FTP). Because it is an open network and access is not terribly expensive, using the Internet for EDI can be more cost effective for companies with limited means. It has the potential to provide them with access to large companies who continue to rely on large, traditional EDI systems. The low cost associated with open EDI also means that more companies are likely to participate. This is important because the level of value for participants often increases along with their number. However, this also presents a dilemma for large companies who have invested a considerable sum in traditional EDI systems. Furthermore, Internet Service Providers (ISPs) usually do not offer the kinds of EDI-specific services provided by VANs.

While the automotive and retail industries have experimented with open EDI for some time, the efforts didn't result in widespread adoption by small suppliers, usually due to cumbersome requirements like the installation of on-site software. Incorporating EDI into e-marketplaces was an approach that held more potential. In March 2000, an e-marketplace called the WorldWide Retail Exchange (WWRE) was established. It allowed suppliers and retails in various industry sectors – including retail, general merchandise, food and drugstores – to conduct transactions over the World Wide Web. After one year of operation, the WWRE had 53 retailer members with combined annual turnover of $722 billion. Leading retailers, among them Kmart, Rite Aid, Best Buy, and Target, planned to offer a Web-to-EDI translation service on WWRE so it would be easier for smaller suppliers to do business with them. In this arrangement, the retailers send purchase orders to a data center where they are translated to a language that can be read with a Web browser like Internet Explorer or Netscape Navigator. Suppliers are then notified about the PO and allowed to respond. This is a break from true EDI, since orders are handled manually by suppliers.

In addition to the Internet, intranets (private internets) and extranets (links between intranets and the Internet) also showed potential for EDI. According to The International Handbook of Electronic Commerce, "The Extranet makes it possible to connect several organizations behind virtual firewalls."

Example: Suppliers, distributors, contractors, customers, and trusted others outside the organization can benefit from establishing an Extranet. The Internet is used to provide access to the public; the Intranet serves the internal business; Extranets provide a critical link between these two extremes.

Extranets are where the majority of business activity occurs. They enable commerce through the Web at a very low cost and allow companies to maintain one-to-one relationships with their customers, members staff and others."

Communication Standards

As previously mentioned, when companies use EDI to exchange information, translation software is an important part of the process. During EDI, information is usually translated to and from one of several different standard languages, including ANSI X12 and EDIFACT. These languages are more flexible than custom standards developed by individual companies for their specific use.

Because of its reliability and flexibility, ANSI X12 was the most widely used North American standard in the early 2000s. Also called ASC X12, ANSI X12 was developed by the American National Standards Institute (ANSI), which administrates and coordinates voluntary industry standardization within the United States. In addition to its prevalence in North America, this standard also was used in Australia and New Zealand.

Created in 1987 with the cooperation of the United Nations, Electronic Data Interchange for Administration Commerce and Transport (EDIFACT) standards combine the best aspects of ANSI X12 and a standard known as United Nations Guidelines for Trade Data Interchange (UNTDI). Because it is so universal, EDIFACT is suited for use in international EDI. Although EDIFACT was becoming increasingly popular in the early 2000s, it lacked the comprehensiveness of ANSI X12.

In addition to ANSI X12 and EDIFACT, other EDI standards also exist, including Global EDI Guidelines for Retail (GEDI), used within North America for international trade; the grocery industry's Uniform Communication Standard (UCS); Voluntary Inter-Industry Commerce Standards (VISC), used by retailers of general merchandise; Warehouse Information Network Standard (WINS), used by public ware-houses; TRADACOMS, created by the Article Numbering Association and used by retailers in the United Kingdom; and NACHA, developed by the National Automated Clearing House Association and used for transactions in the banking industry.

For companies using open EDI, a language called extensible markup language (XML), similar in some respects to hypertext markup language (HTML), allows users to share information in a universal, standard fashion without making the kinds of special arrangements EDI often requires and regardless of the software program in which it was originally created.

Source: http://ecommerce.hostip.info/pages/384/Electronic-Data-Interchange EDI.html#ixzz0Vn3Q9dfK

13.5 E-commerce

This is an abbreviation for electronic commerce, and is usually defined as the conduct of business online, via the Internet. There is a wide array of definitions used to describe business-to-business (B2B) and business-to-consumer (B2C) E-commerce, the two forms that are relevant to operations management. Business-to-consumer is the exchange of services, information and/or products from a business to a consumer, as opposed to business-to-business which is between one business and another. Some studies have used a fairly strict definition that requires that business is done electronically without any human involvement. In the narrow definition of e-commerce, it would require that firms have extensive websites linked to ERP, SCM, and/or CRM systems.

Other definitions used by the European Commission and the United Nations have been fairly broad, stating that B2B and B2C e-commerce are any commercial transaction done between two businesses or between businesses and consumers using some form of electronic technology. This includes the sharing of various forms of business information by any electronic means (such as electronic mail or messaging, World Wide Web technology, electronic bulletin boards, smart cards, electronic funds transfers, and electronic data interchange) among suppliers, customers, governmental agencies, and other businesses in order to conduct and execute transactions in business, administrative, and consumer activities.

Early electronic commerce was the preserve of large companies because the systems required large investments to build or lease mainframes, with complex, purpose-specific software, proprietary networks and massive systems integration. Today, however, users of all kinds need only a PC and a phone line to take advantage of the growing number of public and private networks that use standard protocols such as TCP/IP. E-commerce is not limited to the Internet

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and Web-based systems to perform transactions, because it includes proprietary services also. This "scalability" and "choice" has put small businesses on an equal footing with large corporations and created opportunities for buyers, sellers, and new intermediaries to create value in electronic channels. It offers enormous opportunities for both developed and modernizing countries alike.

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Scope of e-Commerce

Business-to-business services	Business-to-consumer services
Traditional E-commerce • EDI and EFT • Messaging/E-mail • Fax	Messaging services • E-mail • Fax
Online Information services, eg Lexis-Nexis	Online information services, e.g. America Online, CompuServe
Electronic marketplace/transactions, eg industry, Net, electronic malls	Electronic marketplaces/transactions, eg. Internet home shopping

E-commerce means more choices, convenience and lower prices for consumers. It also provides new ways for businesses to grow and meet customer needs, and important benefits and cost-savings for governments and the people they serve. Its growth has been phenomenal. In 2000, the total investment in infrastructure exceeded $200 billion. By 2002, global revenues associated with electronic commerce had crossed $500 billion. This investment and growth is attributed to the value created by B2B marketplaces to:

1. Expand everyone's market reach.
2. Generate lower prices for buyers from the ability of buyers to reach more suppliers or the most efficient supplier and from increased price competition and, in some cases, access to surplus inventory stocks,
3. Cut the cost of the buyers' operations by providing services that significantly reduce the cost of B2B procurement processes, which traditionally consume much staff time and effort, and
4. Finally, help these marketplaces identify industry's best practices.

The first wave of e-commerce was the establishment of independent online companies such as Paper Exchange and E-Steel who used a readily understood business model – charge a small fee for matching up buyers and sellers. By some estimates, more than 1,000 such E-marketplaces – for products that ranged from commodities such as lumber to specialized components such as airplane parts – managed to receive funding.

These marketplaces were initially designed to reduce bid-ask spreads and to bring down transaction costs by matching buyers with suppliers and enabling suppliers to trade with one another – the very kinds of procurement-based benefit that would be expected of an efficient marketplace. Most independent, fee-based marketplaces could not provide real economic value as they were not able to achieve scale volumes.

As volumes can be achieved only if suppliers and buyers invest to integrate their systems and to manage the change process actively in their buying organizations, in the second wave of B2B, large incumbents took matters into their own hands, banding together into consortia with their current trading partners and competitors. During the year 2000, an estimated $10 billion investment in B2B was made for public consortia-backed e-marketplaces alone.

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Example: This included GM-Ford-Daimler Chrysler who banded together into consortia with their current trading partners and competitors, a joint venture now called Covisint. Other well-known examples include Forest Express and Aero Exchange International, in the forest products and airline industries, respectively.

There are three types of traditional B2B marketplaces:

1. Controlled by sellers,
2. Controlled by buyers, and
3. Controlled by neutral third parties.

Marketplaces controlled by sellers are usually set up by a single vendor seeking many buyers. Its aim is to create or retain value and market power in any transaction.

Example: Cisco Systems has set up a corporate website that enables buyers to configure their own routers, check lead times, prices, and order and shipping status, and confer with technical experts. The site generates $3 billion in sales a year.

Marketplaces controlled by buyers are set up by or for one or more buyers with the aim adding value to the buyer and providing negotiating power. Many involve an intermediary, but some buyers have developed marketplaces for themselves.

Example: Japan Airlines, a big purchaser of in-flight consumable items such as plastic rubbish bags and disposable cups, posts procurement notices online in order to find the most attractive suppliers.

Marketplaces controlled by neutral parties involve third-party intermediaries who match many buyers to many sellers.

Example: Fast Parts is one such intermediary. It operates an anonymous spot market for the trading of overstocked electronic components. It receives notice of available stock from sellers, and then matches buyers to sellers at an online auction. Sellers get higher prices than they would through a traditional broker; buyers get market-driven prices that are lower than brokers', plus guaranteed quality because Fast Parts inspects the products; and Fast Parts earns up to 8 per cent commission. All parties benefit.

13.5.1 Third-wave B2B Marketplace Models

Using a different classification, Mckinsey in a survey identified five distinct E-marketplace models that differ in the services they provide. The classification is based on the focus and the capabilities that the e-marketplace delivers. Two of the models focus on collecting and distributing information, three on bringing down purchase costs and improving transactional efficiencies. The classification is as follows:

1. ***Liquidity Creators:*** Create liquid dynamic markets between commodity products traded between buyers and sellers.
2. ***Supply Consolidators:*** Identify relevant supply base and conduct purchases.
3. ***Project/Specification Managers:*** Aid in planning and managing complex projects or processes.

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4. ***Transaction Facilitators:*** Transact and execute purchases.
5. ***Aggregators:*** Combine demand within and across buying enterprises to use the resulting market power to achieve lower prices from suppliers.

Market places that exemplify the information-based model help buyers and suppliers cut costs by helping to set appropriate specifications and by streamlining interactions among the parties constituting the value chains. They can also help them collaborate on design and other high-value decisions. Marketplaces for supply consolidators offer search capabilities based on different parameters as well as price data. This information helps customers trade-off cost against quality. Both project/specification managers and supply consolidators develop and control information that would be very hard to duplicate; in addition, supply consolidators offer highly customized, difficult-to-replicate tools.

A new model used by aggregators is that of the "e-distributor". Like distributors in the off-line world, e-distributors take title to the goods they sell, and aggregate those goods for the convenience of buyers. In addition, e-distributors perform a critical service for sellers by reaching hard-to-find buyers, such as small ones. The result, in many cases, is significant extra value for buyers and decent profits for sellers.

The marketplaces based on the other three models – for liquidity creators, aggregators, and transaction facilitators – focus on benefits such as reducing waste and supplier margins and increasing the efficiency of transactions.

Example: TPN Register, a joint venture between GE Information Services and Thomas Publishing, grew out of an initiative within GE Lighting to consolidate purchases. It was then extended across all divisions. Finally, TPN Register expanded beyond GE to include other leading corporations in a buying consortium. The results have been a reduction in processing costs and in order processing time (from a week to one day for GE Lighting), and a 10 to 15 per cent reduction in prices.

One hallmark of third-wave B2B approaches seems to be the idea of choosing a different model for each kind of transaction. Companies purchasing a commodity, for example, might value the liquidity, the transparency, and the price orientation of an online bourse. By contrast, companies making highly specialized purchases might value the possibilities for customization offered by the traditional bilateral relationship between buyer and seller. To use this tailored-solutions approach, buyers must know which category to choose. They must develop a deep understanding of the cost structures of all their various purchases.

The rewards of these models of e-commerce are split three ways. Sellers can reach more customers, gather better information about them, target them more effectively, and serve them better. The marketplaces also create value for the third-party intermediaries that typically organize them. Intermediaries can earn transaction commissions and fees for value-added services such as information capture and analysis, order and payment processing, the integration of buyers' and sellers' IT systems, and consulting services. The best rewards go to buyers, however.

13.5.2 Electronic Banking

The banking business has been revolutionized by computer technology and E-commerce. Successful e-commerce ultimately leads to some form of payment, and ideally this will involve "electronic funds transfer" (EFT). EFTs are initiated through devices like cards or codes that let you, or those you authorize, access your account. Many financial institutions use ATM or debit cards and Personal Identification Numbers (PINs) for this purpose.

In electronic banking, deposits and withdrawals are instantly logged into a customer's account that can be stored on a remote computer. Computer-generated monthly statements are now a regular feature of all progressive banks. The technology of electronic funds transfer, supported by computer networking, allows the amount of each purchase to be immediately deducted from the customer's bank account and transferred to that of the seller. All this has been made possible due to the development of fail safe security technologies. Bank customers have to be protected from Intruders intercepting or accessing confidential information on financial transactions. Some EFT services that are offered include the following:

1. Automated Teller Machines or 24-hour Tellers are electronic terminals that let you bank almost any time. To withdraw cash, make deposits, or transfer funds between accounts, you generally insert an ATM card and enter your PIN. Some financial institutions and ATM owners charge a fee, particularly to consumers who don't have accounts with them or on transactions at remote locations.

2. Direct Deposit lets you authorize specific deposits, such as paychecks and Social Security checks, to your account on a regular basis. You also may pre-authorize direct withdrawals so that recurring bills, such as insurance premiums, mortgages, and utility bills, are paid automatically.

3. Pay-by-Phone Systems let you call your financial institution with instructions to pay certain bills or to transfer funds between accounts. You must have an agreement with the institution to make such transfers.

4. Personal Computer Banking lets you handle many banking transactions via your personal computer. For instance, you may use your computer to view your account balance, request transfers between accounts, and pay bills electronically.

5. Point-of-Sale Transfers let you pay for purchases with a debit card, which also may be your ATM card. The process is similar to using a credit card, with some important exceptions. While the process is fast and easy, a debit card purchase transfers money – fairly quickly – from your bank account.

6. Electronic Check Conversion converts a paper check into an electronic payment at the point of sale or elsewhere, such as when a company receives your check in the mail. The check is processed through an electronic system that captures the banking information and the amount of the check. Once the check is processed, the company can present the check to your bank electronically and deposit the funds into their account.

Banks are moving to shift their customers to electronic channels – and cross-marketing related financial services such as brokerage and travel along the way. So-called smart cards and stored value cards are now considered a part of e-commerce. The communications element may not always be obvious, but somewhere in the background, computer accounts are usually being credited and debited.

New developments are making banking electronically more safe and at the same time improving the quality of service. Transactions are faster and also more convenient; performed at any hour of the day or night, often regardless of location. Much e-commerce may soon be performed using a mixture of voice recognition and text messaging from mobile telephones. New systems use speech recognition to verify the user's identity to make payment without human involvement.

The reduced costs of processing and documentation in financial transactions makes electronic banking more competitive compared to traditional banking. In 2002, this resulted in over $33 billion in transaction revenues being transferred from the physical to the electronic value chain in the US alone.

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Caselet

E-commerce-watch on Encryption Code Compliance

– *by Thomas K Thomas and Rahul Wadke*

Online banking operations and e-commerce transactions including purchase through credit cards may be open to Government surveillance as a fallout of the recent Blackberry controversy.

The Department of Telecom is now taking steps to ensure that all providers of Internet services strictly follow the prescribed encryption code. As per the existing law, all Internet-based service providers are required to submit a decryption key to the Government if they use more than 40 bit encryption code to secure the transactions.

Encryption codes are essentially a way to scramble information sent online in such a way that only the desired recipient has the key to unscramble it and convert it back to its original form.

However, as it was found out in the Blackberry case, a number of service providers are not strictly following the rule and have not submitted the decryption code. The issue came to light when telecom operators providing Blackberry services told DoT last week that the Government was singling out one service for allegedly violating the encryption laws.

Most of the e-commerce web sites like those selling airline and movie tickets and banking application web sites use more than 128 bit encryption code. The higher code is required to keep the transactions secure. The problem with using higher encryption codes is that the Indian security agencies find it impossible to track any specific transaction unless they have the decryption codes.

However, the Internet Service Providers termed DoT's policy as archaic and said that they have already requested DoT to raise the permitted levels from 40 bits to at least 128 bits in line with the changing technology. "The existing encryption laws were made when Internet services were just beginning to take shape in the country. It is really unfair to stick to the same standards when technology is enabling more secure transactions and highly complex transactions. If DoT insists on the 40 bit encryption then it will be taking the Internet back to the dark ages," said Mr Rajesh Chharia, President, Internet Service Providers Association.

Industry experts said that DoT's policy was not practical on two counts. First, no company will give away its patented codes to leaky Government departments as it could make e-commerce applications unsecure and, therefore, useless. Second, under the existing rules, the procedure for submitting decryption keys, which is in digital form, has not been laid out. So even if anyone was bold enough to give the code to the Government, they would not know how to submit it. "In developed countries like the US there is no limit on the encryption code. Monitoring is done by their security agencies using the most sophisticated technology. DoT should invest in setting up monitoring centres which can do the job without limiting the scope of Internet services," said Mr Amitabh Singhal of Elxess Consulting Services.

Source: thehindubusinessline.com

13.5.3 Scope of E-commerce

As e-commerce spreads through an industry, those that understand and use the economics of the electronic marketplace will gain competitive advantage over those that do not. For most

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incumbents, e-commerce will require broad changes in organizational approach and structure, as well as in skills, mindset, human resources, and measures of economic success. Many will have to cannibalize existing businesses or channels and risk de-motivating the traditional organization while building the new.

Success will involve piloting new approaches, mastering new technologies, challenging conventional market definitions, surviving an initial period of low revenues, and perhaps cannibalizing core businesses. But the potential rewards are great – a new platform and set of tools for competing in a new and dynamic marketplace.

The business processes and decision support systems have a direct impact on the costs and revenue of organizations. However, many companies that own information think it gives them a crucial competitive advantage and therefore fear sharing it freely. This information might include supply-and-demand forecasts, reports of inventory levels at points along the supply chain, and market-tested predictions, the price of futures, etc. Such information would benefit companies up and down the supply chain.

Exchanges will deliver all their benefits, when the idea of confiding financial data to an exchange does not generate skepticism.

Example: Dell Computer and Wal-Mart, derive a competitive advantage from their exclusive collaborations and from the proprietary sharing of information with their suppliers.

E-marketplaces have encountered problems in seeking to streamline tasks (such as production planning, inventory control, and scheduling) that lie closer to the heart of supply chain management. To devise solutions, it will be necessary to analyze what exchanges can and can't do. They will never reduce the time it takes to deliver goods physically. But since the information flow in supply chains is typically linear, fragmented, and inaccurate, they can make a vast difference in this area.

Consortia, stand-alone marketplaces, and perhaps other, as yet undeveloped online structures hold out the promise of facilitating every kind of collaboration between buyers and sellers. Such marketplaces might even help buyers and sellers partially integrate their operations, allowing them to improve their supply chains, and to work jointly on product designs, as is already apparent from developments like world-wide sourcing.

The unifying feature of collaboration on this model is the sharing of real time information and building sustainable partnerships.

Task Give examples of any two companies that have pioneered in e commerce and mention the products which they deal in. Also give a brief about their high selling products.

13.6 Requirements for Supply Chain Management

There are two major forces that drive the supply chain management. First, is that there is the new communications technology available now that allows managers to actively manage a supply chain. Second, customers are demanding lower prices and better products and services. To meet their customers' demands, firms are optimizing the entire supply chain. Supply chain management allows all the firms in a supply chain to look beyond their own objectives to the objective of maximizing the final customer's satisfaction. The payoff for supply chain members that can do this is increased profits for their shareholders.

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The largest barrier to successfully managing a supply chain is perhaps the human element. Failure to correctly manage the issues of trust and communication will abort any attempt to manage the supply chain. When there is a lack of trust and communication, the supply chain's members will soon succumb to greed or suspicion that other members of the supply chain are profiting at their expense. When the communication is not adequate, the supply chain will not improve its response enough to increase profits for its members.

Without an increase in profits, the efforts to manage the supply chain will be reduced, because there will be no reward for actively managing it.

Supply chain management requires an unprecedented level of cooperation between the members of the supply chain. It requires an open sharing of information so that all members know they are receiving their full share of the profits. Since many of the firms in a supply chain do not have a history of cooperation, achieving the trust necessary for supply chain management is a time-intensive task.

Another way that the firms in the supply chain can save money is by ensuring that their marketing strategies correspond to the supply chain's capabilities – i.e., from their position in the supply chain they can actually provide what the customer wants. They are also able to gain money by improving the supply chain's capabilities to match the market demand with a decreased level of inventory. Firms are able to do this because they have additional information to forecast needs and as the lead time is reduced, their need to forecast is reduced. This reduced need to forecast reduces the need to carry inventory stocks for the just-in-case scenario.

13.6.1 Implementing Supply Chain Management

A firm in the supply chain must initiate the attempt to form partnerships and actively manage the supply chain. Often a firm that has a large amount of market power in the chain will become the leader of the supply chain. This firm needs to justify the effort to manage the supply chain by explaining the benefits that will accrue to each member in the supply chain and to itself. To do this, the supply chain leader must show the partners where the improvements in the supply chain will arise and how these will lead to a gain for everyone. To establish trust among the members of the supply chain, the lead firm must also suggest how communication can be opened up and how every member will be ensured that it is receiving its fair share of profits.

Example: Wal-Mart is a good example to showcase this. For years it has gathered extensive data on customer buying patterns. Wal-Mart has used this data internally to manage its own layouts and inventory. Now it is beginning to share all of this data with its most trusted suppliers. This will allow the supplier who knows how to take advantage of this data an opportunity to improve service to Wal-Mart while decreasing its own costs.

Managing a supply chain is more complex and difficult than managing an individual firm. But, the principles of management used to integrate a firm's own internal functions also apply to managing the entire supply chain.

Example: A well-understood phenomenon in the management of a firm is that there is always a bottleneck that constrains sales.

This bottleneck may be internal to the firm (a process that cannot produce enough to meet demand) or it may be external to the firm (market demand that is less than the capacity of the firm). This principle applies to the entire supply chain. While the supply chain is driven by customer demand, it is constrained by its own internal resources.

One difference is that these resources may not be owned by the same firm. It is possible for the output of an entire supply chain to be limited because one firm does not have capacity to meet surging demand. It is also possible for every firm in the supply chain to be operating at a low utilization because there is not enough demand in the market for the products from the supply chain. There are bottlenecks inside the supply chain just as there are bottlenecks inside firms. To properly manage the supply chain, its members must be aware of the location of their bottlenecks internally and also of the bottlenecks in the supply chain.

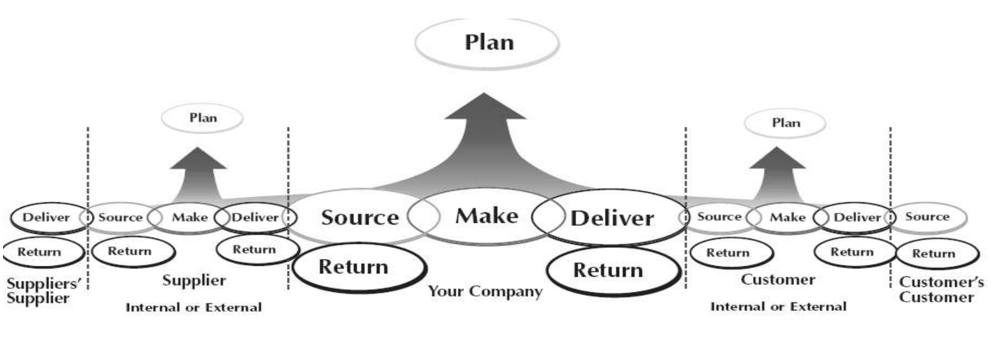
13.6.2 Basic Understanding of the SCOR Model

The Supply Chain Operations Reference model (SCOR) has been developed by the Supply Chain Council as the cross-industry standard for supply-chain management. The SCOR model is based on a benchmarking process and used to measure the performance of an existing supply chain and its related processes. It covers customer interactions from order entry through paid invoice, product transactions and market interactions from understanding demand to fulfilling individual orders.

The SCOR model, whose conceptual framework and linkages are shown in Figure 13.5, is a process reference model that expands to analyze processes involving cross-functional activities. It looks at five distinct management processes that constitute the basic elements of a value chain:

1. ***Plan:*** Processes that balance aggregate demand and supply to develop a course of action which best meets sourcing, production and delivery requirements;
2. ***Source:*** Processes that procure goods and services to meet planned or actual demand;
3. ***Make:*** Processes that transform product to a finished state to meet planned or actual demand;
4. ***Deliver:*** Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management and,
5. ***Return:*** Processes associated with returning or receiving returned products for any reason. These processes extend into post-delivery customer support.

Figure 13.5: The SCOR Model



The model uses a four-level pyramid; Process-Type Level; Configuration Level; Process Element Level; and Implementation Level - that defines the steps a company needs to take to measure and improve supply chain performance.

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The process involves comparing practices and procedures to those of the 'best' to identify ways in which an organization (or organizations) can make improvements. This is accomplished through benchmarking. Benchmarking is an effective means of determining the supply chain's performance relative to those of other organizations.

Metrics can include a wide variety of performance measures: delivery (in full, on time, in specification), order fulfillment, fill rate (for make-to-stock), lead time or supply-chain response time, production flexibility, total cost, realized margin, warranty costs, returns processing costs and more. A company is not likely to meet best practice norms in all metrics, but the metrics it should focus on should reflect its customer needs and market realities.

The model draws attention to process gaps rather than pointing to specific departments' performance. This is meant to help the company communicate without ambiguity and help measure, manage and refine processes. It also helps the organization quantify operational performance and set improvement targets based on best practices in similar companies. However, this needs to be related to functional performance measures. Organizations have to devise means to relate departmental performance metrics to the SCOR model.

The challenge in SCM is to integrate the functional performance measures into overall measures that will reflect the performance of the entire supply chain. The performance measures must show not only how well you are providing for your customers (service metrics) but also how you are handling your business (speed, asset/inventory, and financial metrics). Measurement is also an ideal way to communicate requirements to other members of the supply chain and to promote continuous improvement and change.

Many organizations are willing to receive information from other supply chain members but are reluctant to share their information with other members. The issue of the organization's willingness to share information with other supply chain members is something that needs management attention and a solution to make the SCM initiative successful. Working together, organizations can better satisfy the customer's requirements for quality, cost, product and service.

13.7 Decisions in Supply Chain Management: The Steps

Supply chain management involves proactively managing the two-way movement and coordination (that is, the flows) of goods, services, information, and funds from raw material through end user. A company with a "supply chain orientation" is one that recognizes the strategic value of managing operational activities and flows across a supply chain. Its decisions fall into three categories or phases:

Supply Chain Design

Supply Chain Design is a strategic decision. It reflects the structure of the supply chain over the next several years. It decides what the chain's configuration will be, how resources will be allocated, and what processes each stage will perform.

Successful design requires a high degree of functional and organizational integration. In order to do so, it is essential to develop supply chain process maps (flow charts) for major supply chains and their related processes helps establish an understanding of the supply chain. There should be a clearly understood mapping convention to be utilized, along with other information requirements. The objective of this exercise is to develop supply chain maps that present all supply chain entities along with key processes.

From this exercise will flow such decisions as the location and capacities of production and warehousing facilities, the products to be manufactured or stored at various locations, the modes of transportation, and the type of information system to be utilized. The organization

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must also identify key and critical supply chains components. It must be knowledgeable regarding its part of the supply chain and also must understand how the part interfaces with the other parts of the supply chain.

The supply chain configuration should support the organization's strategic objectives.

Example: In the case of TI Cycles discussed in Module 1, its decisions regarding the location and capacity of its manufacturing facilities at Aurangabad, the joint manufacturing agreement with Avon Cycles and distribution network are all supply chain design or strategic decisions.

These are long-term decisions and are very expensive to alter on short notice. Consequently, when companies make these decisions, they must take into account uncertainty in anticipated market conditions over the next few years.

Supply Chain Planning

In the planning phase, companies define a set of operating policies that govern short-term operations and are normally determined on an annual basis. These decisions are made within the supply chain's configuration. Planning starts with a demand forecast for the coming year. Based on the demand, an annual plan is worked out. Decisions regarding which markets will be supplied from which locations, outsourcing and sub-contracting, inventory policies, etc. are made. Planning, in other words, establishes parameters within which a supply chain will function over a specified period of time.

Once the key supply chains have been identified, one must identify the supply chain member organizations (suppliers and customers) that are considered most critical to the organization's supply chain management efforts. In selecting external members, several issues should be addressed.

1. SCM endeavors are likely to be more productive if participating organizations are not direct competitors. There may be limits to collaborative supply chain efforts when both buyer-supplier and competitor relationships exist between participating organizations.
2. All organizations and their representatives must be pursuing similar goals. This does not mean that each organization should have identical goals, but that their respective goals must be compatible with the overall SCM initiative.
3. SCM initiative is unlikely to be successful unless all members from each organization involved feel they are benefiting from participation. SCM efforts have to be focused where the involvement is beneficial to all the members.

In well managed organizations, in the planning phase uncertainty in demand, exchange rates, and competition over this time horizon are included in the decisions. Given a shorter time horizon and better forecasts than the design phase, the planning phase tries to exploit the supply chain design to optimize performance.

Supply Chain Operation

This has a short-term time horizon, monthly, weekly or daily. The focus, during this phase, is on individual customer orders. At the operational level, within planning policies, the goal is to handle incoming customer orders in the best possible manner. Firms allocate inventory or production to individual orders, set a date that an order is to be filled, generate pick lists at a warehouse, allocate an order to a particular shipping mode and shipment, set delivery schedules of trucks, and place replenishment orders.

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Aggregate planning is the basis for decisions at this stage. The aggregate plan serves as a broad blueprint for operations and establishes the parameters within which short-term production and distribution decisions are made. It allows the supply chain to alter capacity allocations and change supply contracts. In addition, many constraints that must be considered in aggregate planning come from supply chain partners outside the enterprise, particularly upstream supply chain partners. Without these inputs from both up and down the supply chain, aggregate planning cannot realize its full potential to create value.

The output from aggregate planning is also of value to both upstream and downstream partners. Production plans for an organization define demand from suppliers and establish supply constraint for customers. If a manufacturer has planned an increase in production over a given time period, the supplier, the transporter, and warehousing partner must be aware of this plan and incorporate the increase in their own plans.

Because operation decisions are being made in the short term, there is less uncertainty about demand information. Given the constraints established by the configuration and planning policies, the goal during the operation phase is to exploit the reduction of uncertainty and optimize performance.

Ideally, all stages of the supply chain should work together to optimize supply chain performance. An important supply chain issue is collaboration with down stream supply chain partners. Slack of co-ordination will result in shortages or oversupply in the supply chain. Therefore, it is important to perform aggregate plans over as wide a scope of the supply chain as is reasonably possible.

13.7.1 Internal Supply Chains

The internal supply chain is that portion of a given supply chain that occurs within an individual organization. The first step in moving towards supply chain management is to develop these internal chains. Internal supply chains can be quite complex. Given the multidivisional, international organizational structures found in many businesses, it is not uncommon for the internal part of a supply chain to have multiple "links" that span the globe. Developing an understanding of the organization's internal supply chain is often an appropriate starting point for firms considering an SCM initiative.

In these multi-divisional structures, the employees of one division often view the "other" divisions in much the same manner as they would external suppliers or customers. In some cases, turf wars between divisions make integrating cross-divisional functions and processes very difficult.

The supply chain has to be seen as a set of interrelated processes rather than a series of discrete, non-aligned activities. Process maps are developed to understand the overall internal supply chain linkages. These maps provide the basic information required to link the different entities. Examples of key processes and associated entities include order information from sales, order entry for materials planning, order preparation by purchasing, manufacturing, or warehousing, and order shipment for distribution and transportation. Each key process is documented along with current performance information.

It is beneficial when the different divisions understand the steps in their portion of the supply chain and "what happens" outside their part of the process. Developing supply chain process maps (flow charts) for major supply chains and their related processes is a basic requirement to establish an effective supply chain.

13.7.2 External Supply Chains

Once one understands the internal supply chain, one must extend the analysis to the external portion of the supply chain (i.e., key suppliers and customers). This is an important step, as significant opportunities for improvement often lie at the interfaces between the various supply chain member organizations. This step also adds a greater level of complexity, given that multiple organizations and their representatives are now participating in the analysis.

At this point in the analysis, the organization needs to focus its efforts on those supply chains that are most important to the organization's success. The organization determines which products should be produced internally or purchased. Once the decision is made to purchase a product or service from external suppliers, purchasing is brought into the process.

13.7.3 Supply Chain Processes

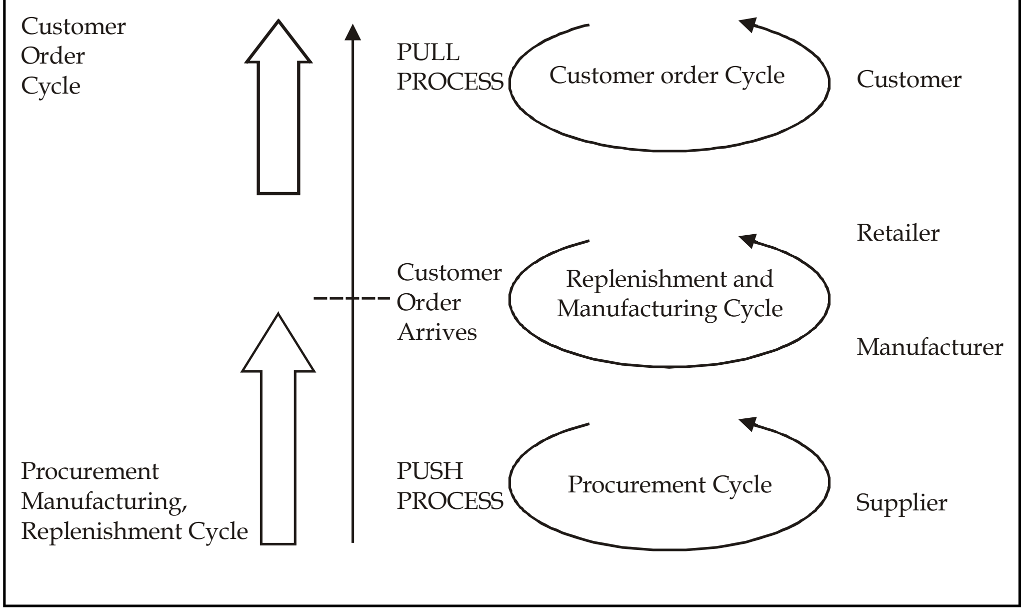
The management of the supply chain covers everything from product development, sourcing, production, and logistics, as well as the information systems needed to co-ordinate inventory, cost, information, customer service, and collaboration relationships. A supply chain is a sequence of processes and flows that take place within and between different stages and combine to fill a customer need for a product.

Push/Pull View of Supply Chain

Processes in a supply chain are divided into two categories depending on whether they are executed in response to a customer order or in anticipation of customer orders. Pull processes are initiated by a customer order whereas push processes are initiated and performed in anticipation of customer orders.

Example: Tata Steel that collects orders that are similar enough to enable the manufacturer to produce in large quantities. In this case, the manufacturing cycle is reacting to customer demand (referred to as a pull process).

Figure 13.6: Push/Pull Processes for a Retail Network



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Hindustan Lever Ltd. a consumer products firm, which must produce in anticipation of demand. In this case, the manufacturing cycle is anticipating customer demand (referred to as a push process).

Figure 13.6 shows graphically the push/pull system in a retail network. It can be clearly seen from the figure that in the pull processes, customer demand is known with certainty at the time of execution, i.e., it is executed after the customer order arrives, whereas for a push process, demand is not known and must be forecast as the customer order is yet to arrive. Therefore, pull processes may also be referred to as reactive processes because they react to customer demand. Push processes may also be referred to as speculative processes because they respond to forecasted rather than actual demand. The push/pull boundary in a supply chain separates push processes from pull processes.

A push/pull view of the supply chain is very useful when considering strategic decisions relating to supply chain design. This view forces a more global consideration of supply chain process as they relate to a customer order. For instance, it could result in responsibility for certain processes being passed on to a different stage of the supply chain if making this transfer allows push process to become a pull process. One clear distinction between the two supply processes is that a supply chain that has fewer stages and more pull processes has a significant impact on improving supply chain performance.

Caselet

Wal-Mart's "Green" Supply Chain Management

Supply chain management has been the cornerstone to Wal-Mart's success and remains their primary competitive advantage in the retail/department store industry. Their distribution system is generally regarded as the most efficient and they have an approach to supply chain management that has long emphasized visibility through the sharing of information with their suppliers. Although there are hundreds of logistical functions which allow Wal-Mart to be the price and logistics leader, the focus will be primarily on the company's newly adopted strategy of making logistical processes "green" and more environmentally conscious. According to the Supply Chain Management Review, Wal-Mart CEO Lee Scott committed the company to three ambitious goals: to be supplied 100 percent by renewable energy; to create zero waste; and to sell products that sustain Wal-Mart's resources and the environment. Wal-Mart's 14 Sustainable Value Networks, the Network's structure, new "green" logistics technologies, and additional future initiatives will be considered along with counter arguments which suggest that Wal-Mart's green initiative is simply unsustainable. The main sticking point seems to be the same one that has long held back the adoption of better light bulbs, home solar panels, or hybrid cars. Upfront costs are unavoidable; and the promise of potential savings down the road does not resonate with consumers, or smaller Wal-Mart suppliers, the same way it does with big corporations. So that's the big question: How much will Wal-Mart invest in green technologies now to clean up its act down the road?

Introduction

Wal-Mart has undergone many growth stages since Sam Walton first decided to be the best retailer in the world. His initial strategy was to target low-income families in rural areas by offering significantly lower costs. When David Glass took over in 1988, Walton's mission was truly realized through the use of technology in distribution and supply chain logistics, which allowed Wal-Mart the opportunity to cut costs and lower prices for end users. Lee Scott took the reins in 2000 to steer Wal-Mart toward sustainability. Scott's

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business model to strengthen supply chain management processes by "going green" was a strategic decision that positively impacted Wal-Mart's growth, distribution techniques, and corporate identity. His knowledge of distribution systems and push for sustainability has transformed the company into an eco-friendly powerhouse that continues to cut costs and remain at the frontier of distribution systems technology.

Background

Wal-Mart leadership has done well to put the right people in the right seats on the bus to drive the company forward. Founder and original Wal-Mart CEO Sam Walton strategically chose his successor David Glass to lead the company in 1988. Art Turock claims that "the most impactful decision Sam Walton made during his reign was to select and develop successors equipped to lead Wal-Mart to the next level of complexity" (Turock, 2004). From 1988 to 1999, CEO David Glass transformed the company from just a retailer into a retail distributor, using technology to develop Walton's original goal while staying in line with his core values. While Sam Walton built his strategy on low prices to the masses, CEO David Glass enhanced his growth strategy through the use of technology. Sophisticated technology boosted supply operations such that Wal-Mart's efficient retail stores became the manifestation of a fast and flawless distribution business. When Glass succeeded Walton, he believed that "technology would ultimately drive this business to be the size that it is" which was the fundamental difference that set his approach apart from that of Walton's (Turock, 2004). The late 80s and 90s began a technology boom, with the computer industry making rapid advancements. Glass identified this as a strategic opportunity to enhance business and distribution at an early stage in development. Emphasizing visibility through the sharing of information with suppliers, Glass reframed the company strategy in terms of how to be the low-cost operator and low-cost leader by focusing on logistics and distribution. A more advanced distribution system would move product faster and more efficiently, allowing Wal-Mart to maximize use of their suppliers as well as internal distribution lines. Glass used cutting edge technology to create a logistical competitive advantage in "an industry with high volume, inelastic pricing, fragmented market share, and inefficient distribution" (Turock, 2004). Because of David Glass' work, Wal-Mart's supply chain and distribution system is now regarded as the most efficient and remains their primary competitive advantage in the retail industry.

Going Green

Requirements

Lee Scott took control of Wal-Mart in 2000 with a newly adopted strategy of making logistical processes more economically friendly. "Green" logistics, at its core, means implementing a system that can independently monitor overseas suppliers to make sure they meet social and environmental standards. Though the push for becoming environmentally friendly is important, a global company like Wal-Mart must consider the transformation's effect on the bottom line. Lee Scott saw the two goals as intertwined: "being a good steward of the environment and being profitable are not mutually exclusive. They are one and the same" (MSNBC, 2005). Scott provided an example by calculating that improving fuel mileage efficiency in the trucking fleet by one mile per gallon would save more than $52 million per year. The move toward sustainability also integrated Corporate Social Responsibility (CSR) into Wal-Mart's business model. Ideally, this CSR policy would function as a built-in self-regulating mechanism where Wal-Mart could monitor and ensure their adherence to laws, ethical standards, and international norms. This CSR policy would be a way for the company to embrace responsibility for the impact of their activities on the environment, consumers, employees, communities, stakeholders and all other members of the public sphere.

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The Next Level

Wal-Mart has attempted green initiatives before, but Scott's plan is different and has the potential for success based on many reasons. In the past, Wal-Mart dealt with environmental issues defensively rather than cooperatively, proactively, and as opportunities for profit. In 1989, in response to letters from customers about environmental concerns, the company launched a campaign to convince its suppliers to provide environmentally safe products in recyclable or biodegradable packaging. However, this large-scale effort was met with some skepticism from commentators who believed that it was intended to generate benefits for Wal-Mart at the expense of its suppliers. Nevertheless, the company did earn some goodwill among environmentalists as the first major retailer to speak out in favor of the environment. When vendors claimed they had made environmental improvements to products, Wal-Mart began promoting the products with green-colored shelf tags. It should be noted that although Wal-Mart promoted these products, the company did not actually measure or monitor the improvements. Regardless, the company sold as many as 300 products with green tags at one point. By the early 1990s, the green tag program disappeared altogether, and environmental issues slipped off of the Wal-Mart's list of strategic priorities.

The new sustainability strategy needs to be deeply embedded in Wal-Mart's operations and supply chain management to meet the ambitious goals set in 2005. In the words of Lee Scott, "We recognized early on that we had to look at the entire value chain. If we had focused on just our own operations, we would have limited ourselves to 10 percent of our effect on the environment and eliminated 90 percent of the opportunity that's out there" (Plamback, 2007).

Wal-Mart's leadership must therefore evaluate the entire value chain as a means of implementing sustainability through distribution systems. Creating metrics for analysis is paramount to Wal-Mart's ability to monitor corporate operations and global suppliers to be able to support their real efforts for improvement with substantial data.

Ambitious Goals

In late 2005, Wal-Mart President and CEO Lee Scott gave his first presentation broadcast to over 1.5 million employees in over 6,000 stores and each of its suppliers. He laid out a detailed summary regarding Wal-Mart's new sustainability initiative to make a positive impact and greatly reduce the impact of Wal-Mart on the environment in order to become the "most competitive and innovative company in the world" (Plambeck, 2007). In his speech, Lee Scott laid out three very ambitious goals in which he vowed Wal-Mart would:

1. Be supplied 100 percent by renewable energy in the very near future
2. Create zero waste
3. Sell products that sustain Wal-Mart's resources and the environment

Clearly, Wal-Mart is trying to differentiate itself in an area where it was once considered a laggard. Even some of the harshest Wal-Mart critics have started to agree that the company has begun to make good on its promises. Obviously, these goals can seem overly ambitious to most, but they should not seem inconceivable considering Wal-Mart's past success with seemingly unreachable goals.

The three goals were just an introduction to Mr. Scott's speech. He also discussed the following goals:

1. Increase fuel efficiency in Wal-Mart's truck fleet by 25 percent over three years and doubling it within 10 years

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2. Reduce greenhouse gases by 20 percent in 7 years
3. Reduce energy use at stores by 30 percent in 7 years
4. Cut solid waste from U.S. stores and Sam's Clubs by 25 percent in three years.
5. Buying diesel-electric and refrigerated trucks with a power unit that could keep cargo cold without the engine running, saving nearly $75 million in fuel costs and eliminating an estimated 400,000 tons of CO_2 pollution in one year alone
6. Making a five-year verbal commitment to buy only organically grown cotton from farmers, and to buy alternate crops those farmers need to grow between cotton harvests. Last year, the company became the world's largest buyer of organic cotton
7. Promising by 2011 to only carry seafood certified wild by the Marine Stewardship Council, a group dedicated to preventing the depletion of ocean life from overfishing.
8. Buying (and selling) 12 weeks' worth of Restrictions on Hazardous Substances (RoHS)- compliant computers from Toshiba.

Although this may seem like a very large list for a company to accomplish, each of these are attainable and place Wal-Mart in a great competitive position for the future.

Sustainable Value Networks

While Wal-Mart is building value added networks of government agencies, nonprofits, employees and suppliers to "green" its supply chains, the company is using a network approach to lower overall carbon and environmental footprint in order to increase profitability while increasing margins. For years Wal-Mart has been narrowly focused on operations and supply chains, growth, and profits. Recently, Wal-Mart reached out to external stakeholders to try and develop areas of maximum environmental impact and identify key networks which would help achieve these goals. In return for participating in these value-added networks, participants would receive information about as well as a say in Wal-Mart's operations. Tyler Elm, Wal-Mart's senior director of corporate strategy, and Andrew Ruben, Wal-Mart's vice president of corporate strategy and business sustainability, directed Wal-Mart's network leaders to, "derive economic benefits from improved environmental and social outcomes" (Elm, 2007). "It's not philanthropy," he adds. According to a Stanford Social Innovation Review, "By the end of the sustainability strategy's first year, the network teams had generated savings that were roughly equal to the profits generated by several Wal-Mart Supercenters" (Denend, 2008). Below is a list of Wal-Mart's sustainable value networks and how the company plans to accomplish each of the main three goals:

Wal-Mart's Sustainable Value Networks

Each of the 14 networks serves at least one of Wal-Mart's three environmental goals.

Goals	To be supplied by 100% renewable energy	To create zero waste	To sell products that sustain our resources and the environment
Networks	• Global Greenhouse Gas Strategy • Alternative Fuels • Global Logistics • Energy, Design, Construction, & Maintenance	• Operations and Internal Procurement • Packaging	• Chemical Intensive Products • Seafood • Electronics • Food & Agriculture • Forest & Paper • Jewelry • China • Textiles

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At the center of the business sustainability strategy pursued by Wal-Mart is a shift from generating additional value through price-based interactions, relationships with nonprofits, suppliers, and other stakeholders. Through the above networks, Wal-Mart is gaining a system perspective which helps retailers find ways to address environmental issues. In exchange for these suppliers addressing the issues, nonprofit network members gain huge leaps towards their overall missions because of the scale of the operations at Wal-Mart. Suppliers also enjoy not only the stability that more intimate relationships with Wal-Mart brings, but also the guidance and support from Wal-Mart's nonprofit partners.

The Wal-Mart sustainability strategy no doubt looks to be off to a promising start; they must not become complacent and must press-on carefully in order to make these networks sustainable and able to expand without interruption. The first thing they need to do is manage these partnerships carefully in order to keep costs down. They also need to be able to manage the balance between offering "green" and conventional "non-green" products in its stores.

Finally, because of the very high number of nonprofits in the network, Wal-Mart must manage the loss of these partnerships. Individual groups may be unable to get credit for a large reduction on environmental impact. Over time, these groups' inability to be able to demonstrate their impact may cause some problems with their fundraising because donors will demand more and more data on their performance. These problems could eventually cause the nonprofit groups to withdrawal from the networks.

Counter-Arguments to Wal-Mart Going Green

While some stakeholders and management become increasingly confident about the new sustainability initiatives, history dictates that there is reason to worry. Many critics argue that Wal-Mart's green initiative is simply unsustainable. As with many companies attempting to make their business strategy more "green", upfront costs become unavoidable and are simply not worth the investment. Wal-Mart will need to spend in upwards of $500 million per year in order to achieve the goals mentioned earlier in the study. The promise of potential savings down the road does not resonate with consumers, or smaller Wal-Mart suppliers, the same way it does with big corporations. However, it is important to note that Lee Scott stated in 2007, "Tangible profits generated by Wal-Mart's sustainability strategy in the first year of implementation were roughly equivalent to the profits from several Wal-Mart SuperCenters." Intangible benefits, such as public goodwill and improved assurance of supply, are worth much more to the retailer than the profits generated the first year of implementation.

As Wal-Mart attempts to scale up networks and improve upon "green" initiatives, the company faces three possible obstacles:

1. Increased Costs
2. A Sub-Optimal Product Assortment
3. Criticism of Factory Labor Conditions.

Wal-Mart must take these challenges seriously because public reputation is on the line as it makes more and more promises to the public. With increased dependence on a limited number of selected suppliers, Wal-Mart also may face rising prices from the narrow supply base, especially in times of limited resources. Also, with fewer suppliers Wal-Mart may miss opportunities to create innovative products that customers may want but are not necessarily environmentally friendly. Wal-Mart must continue to innovate while managing incremental "green" changes to their supply chain management. Each of the nonprofit partners will continue to push Wal-Mart in choosing product assortment lines.

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Conclusion

According to the 2009 Wal-Mart Sustainability Report, Lee Scott was quoted as saying, "The facet is sustainability at Wal-Mart isn't a stand-alone issue that's separate from or unrelated to our business. It's not an abstract or philanthropic program. We don't even see it as corporate social responsibility. Sustainability is built into our business. It's completely aligned with our model, our mission and our culture." In this case study we have outlined the requirements needed to become a sustainable business, the reason why this initiative is different than others previously attempted by Wal-Mart, goals presented by management, the new value networks, and risks Wal-Mart needs to address. They have already taken major steps including a "green" website where they give tips on how customers can go green and what they can do to reduce their environmental impact. Wal-Mart critics argue that the steady dose of these initiatives is an effort to deflect attention from its work-place policies and its financial performance. They need to continue to invest in its environmental policies as well as address the issues facing their workforce in order to prove these initiatives are not just a public relations stunt. However, if Wal-Mart proves that it is serious about reducing environmental impact and devoted to investing in green initiatives, critics will have to unclench their fists for a round of applause. At least for a moment.

13.8 Performance Optimization

Supply chain performance improves if all stages of the chain take actions that together increase total supply chain profits. A lack of co-ordination can impact the performance. This occurs either because different stages of the supply chain have objectives that conflict or because information moving between stages gets delayed and distorted. Supply chain co-ordination requires each stage of the supply chain to take into account the impact its actions have on other stages.

Today, supply chains consist of potentially hundreds, or even thousands, of independently owned enterprises.

Example: Maruti Udyog has thousands of suppliers from MRF to Motorola – and the number of tiers of the supply chain increases as the chain becomes more complex.

As the complexity of the supply chain increases, very often different stages of a supply chain may have objectives that conflict if each stage has a different owner. As a result, each stage tries to maximize its own profits, resulting in actions that often diminish total supply chain profits.

The success of a SCM initiative largely rests on performance. The traditional company boundaries are changing as companies discover new ways of working together to achieve the ultimate supply chain goal – the ability to fill customer's orders faster and more efficiently than the competition. To achieve that goal, organizations need performance measures, or "metrics", which are formal, well defined processes that can be documented and measured to facilitate supply chain improvements.

Developing and maintaining a supply chain performance measurement system represents one of the more significant challenges faced in Supply chains. The supply chain generally consists of a number of departments each, perhaps reporting to different supervisors. Given the cross-functional nature of many supply chain improvements, metrics must prevent "organizational silo" behaviour which can hinder supply chain performance.

Supply Chain Optimization is the application of processes and tools to ensure the optimal operation of a manufacturing and distribution supply chain. This includes the optimal placement of inventory within the supply chain, minimizing operating costs (including manufacturing costs, transportation costs, and distribution costs).

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13.9 Just-in-Time and Lean Operations

Just-in-Time (JIT) is a term that has often been used interchangeably with Lean Manufacturing. Some say it is a predecessor to Lean Manufacturing, but in any case, it is an essential part of lean manufacturing.

JIT is a management philosophy that strives to eliminate sources of manufacturing waste by producing the right part in the right place at the right time. Waste results from any activity that adds cost without adding value such as moving and storage. JIT improves profits and return on investment by reducing inventory levels, reducing variability, improving product quality and reducing production and delivery lead times. In a JIT system, underutilized (excess) capacity is used instead of buffer inventories to hedge against problems that may arise.

Just-in-time is a movement and idea that has gained wide acceptance over the past decade. As companies became more and more competitive and the pressures from Japan's continuous improvement culture mounted, other firms were forced to find innovative ways to cut costs and compete. The notion of pushing materials in large quantities no longer made sense. Both the financial costs and the required resources of doing so are counter productive in the long run. It is wiser to deliver materials only just before they are needed and only in the quantity required.

A firm cannot implement a JIT system by itself; it must have the complete cooperation of its entire Supply Chain. A large amount of information is needed for a JIT system to operate well. It demands partnerships to be formed and nurtured, almost to the point at which an entire supply chain operates as one firm. Examples of these kinds of partnerships are everywhere in today's business world.

Kanban is a Japanese word meaning flag or signal and is a visual aid to convey the message that action is required. The Kanban inventory control system was an integral part of TPS. JIT uses a Kanban system. It works on the basis that each process on a production line pulls just the number and type of components the process requires, at just the right time. Kanban is usually a physical card but other devices can be used. A Kanban is a card that is attached to a storage and transport container. It identifies the part number and container capacity along with other information. There are two common types of Kanban systems used; the one-card system and the two-card system.

The Two-Card System: The two-card system is the more popularly used Kanban system. It uses two kinds of Kanban cards:

1. *Conveyance Kanban (C-Kanban),* signals the need to deliver more parts to the next work center. It specifies the kind and quantity of product which a manufacturing process should withdraw from a preceding process. The C-Kanban in Figure 13.7 shows that the preceding process which makes this part is forging, and the person carrying this Kanban from the subsequent process must go to position B-2 of the forging department to withdraw drive pinions. Each box of drive pinions contains 20 units and the shape of the box is 'B'. This Kanban is the 4th of 8 issued. The item back number is an abbreviation of the item.

2. *Production Kanban (P-Kanban),* signals the need to produce more parts. It specifies the kind and quantity of product which the preceding process must produce. The P-Kanban on the right in Figure 13.7 shows that the machining process SB-8 must produce the crankshaft for the car type SX50BC-150. The crankshaft produced should be placed at store F26-18. The production-ordering Kanban is often called an in-process Kanban or simply a production Kanban.

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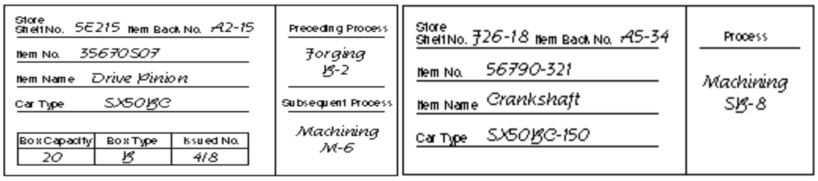
Figure 13.7: C-Kanban and P-Kanban



Each process (area, cell) on the production line has two Kanban 'post-boxes', one for C-Kanbans and one for P-Kanbans. At regular intervals a worker takes C-Kanbans that have accumulated in his process post-box, and any empty pallets, to the location where finished parts (components, assemblies) from the preceding process are stored. Each full pallet has attached to it one or more P-Kanbans which he removes and puts in the appropriate post-box belonging to the process that produced the parts. The worker now attaches a P-Kanban to the pallet and takes it back to his own process area. When this new pallet begins being used its C-Kanban is put back into the post-box. At each process on the line P-Kanbans are periodically removed from their post-box and used to define what parts and quantities to produce next. There are three rules that must be followed:

1. No parts to be made unless P-Kanban authorizes production
2. Exactly one P-Kanban and one C-Kanban for each container
3. Only standard containers are used and they are always filled with the prescribed quantity

The number of kanban card sets required in a particular location can be calculated as:

K = (expected demand during lead time + safety stock)/(size of the container)

If rounding is necessary, K must be rounded up to the next highest integer.

Lean Manufacturing strives to maximize long-term profitability and growth. Kanbans help simplify planning and to fine-tune production to meet changing customer demand of upto ± 10%. The system requires planned monthly and weekly production schedules. Kanbans simplify day-to-day flexibility, hence changes to the production schedule only need to be given to the final assembly process and then automatically work their way back up the line.

Kanban systems can be tightened by removing cards or by reducing the number of parts on a pallet. The effect will be to speed the flow through the process and hence reduce lead times. However, it also makes the system more vulnerable to breakdowns and other causes of dislocation. By identifying the areas within the line that are causing disruption, efforts can be made to improve them. Thus, the overall efficiency of the line is raised by tackling the key points.

A Kanban system is a pull system, in which the Kanban is used to pull parts to the next production stage when they are needed; an MRP system (or any schedule based system) is a push system, in which a detailed production schedule for each part is used to push parts to the next production stage when scheduled. The weakness of a push system (MRP) is that customer demand must be forecast and production lead times must be estimated accurately. The weakness of a pull system (Kanban) is that following the Lean Manufacturing philosophy is essential, especially concerning the elements of short setup times and small lot sizes.

Single Card Kanban systems: In a single-card Kanban system, parts are produced and bought according to a daily schedule and deliveries to the user are controlled by a C-Kanban. In effect, the single-card system is a push system for production coupled with a pull system for delivery to the point of use.

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Single-card Kanban controls deliveries very tightly so that the using work center never has more than a container or two of parts and the stock points serving the work center are eliminated. Single-card systems work well in companies in which it is relatively easy to associate the required quantity and timing of component parts with the schedule of end products. These are usually companies with a relatively small range of end products or products which are not subject to rapid, unexpected changes in demand levels.

Attributes of JIT

Just-in-time has been discussed as a way to control flows of material through sequential processes, with particular emphasis on the pacing by downstream processes of the production and delivery work done by upstream processes. While this and associated issues of inventory control are important aspects of JIT as used in practice, this emphasis misses attributes of JIT that contribute to problem solving, process improvement and the operations-based sustainable competitive advantage often associated with Toyota and its affiliates. These attributes are explained through a real life example.

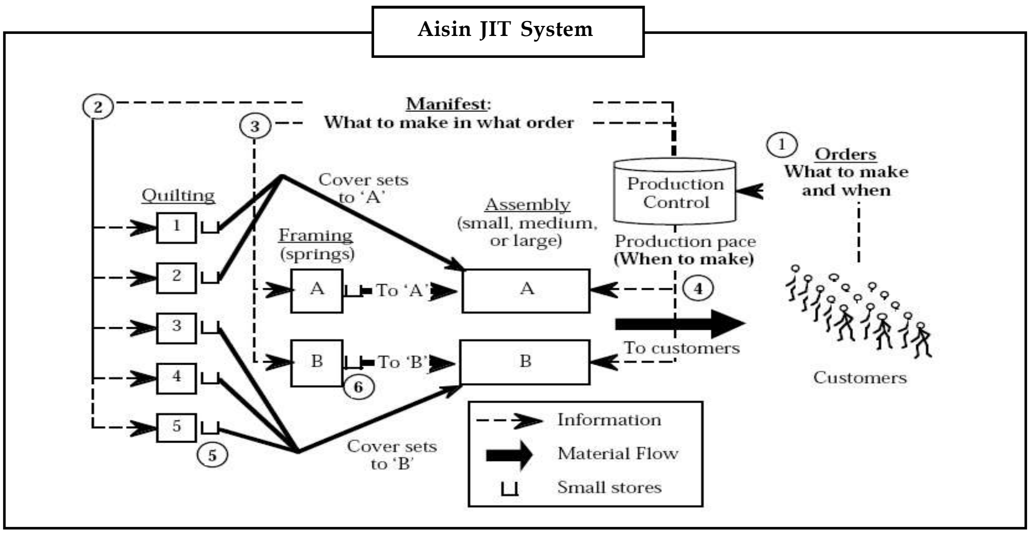
The Aisin JIT System is shown in Figure. Aisin is a first-tier, auto-parts supplier to Toyota. It also manufactures consumer products such as mattresses, sewing machines and computerized bathroom scales.

Customer orders (item 1) determine production mix, volume and delivery timing for the plant. Production control creates printed manifests establishing the production mix, volume, and sequence with one manifest for every mattress and sends the individual manifest to the start of the quilting line (item 2). It also sends one that corresponds to the same mattress to the start of the framing line (item 3).

For every mattress for which a manifest-set was sent to the start of quilting and framing, a separate signal was sent to the end of the assembly line (item 4), indicating that the next mattress was to be taken to shipping.

This signal continued through the system and established for each worker when to produce and deliver one more unit and thereby determined each person's correct production pace.

Example:



Stores, which separated process-stages in the plant, were located between quilting and assembly (item 5) and framing and assembly (item 6). These stores were the only way to transfer units between he feeder and the assembly lines. They operated on a first-in, first-out basis. Therefore, the stores protected the unambiguous production mix and sequence established at the start of quilting and framing. Stores also protected the production rate across process-stages because of their capacity limitations.

As materials were depleted, individual 'Kanban' cards were sent to the person who ordered material thereby automatically authorizing delivery of small batches of replacement supplies. Kanban cards were the only way of reordering certain materials and were used every time a specific customer had to reorder material of a particular type. They went to a specific supplier and established the criteria for a good response (i.e., the card for fabric-1 was different than that for fabric-2 and indicated a pre-agreed quantity, such as 20 meters worth of cloth). The person who received the individual Kanban cards reordered materials by sending a shipment worth of Kanban cards to the external supplier, on an established schedule. By extending the rate and sequence with which customer orders were filled from within the Aisin plant to external suppliers as well, the entire system was linked to the mass customization effort.

The plant transitioned from mass production to mass customization in 1986. The impact of using JIT in spite of continued increases in volume and variety is shown in Table 13.1. One can see the increases in productivity and simultaneous reductions in lead-time and inventory.

Table 13.1: Aisin Mattress Production Historical Mix, Volume and Inventory

	1986	1988	1992	1996	1997
Styles	200	325	670	750	850
Units per day	160	230	360	530	550
Units per person	8	11	13	20	26
Finished goods (days)	30	2.5	1.8	1.5	1.5
Productivity Index	100	138	175	197	208

This transition was achieved despite challenges characteristic of making complex items more general such as multiple process stages, imbalanced and variable process times, product variety and fluctuations in the mix, volume, and timing of demand. Thus, rather than facing static trade-offs along a fixed 'production possibilities frontier' the plant repeatedly improved its manufacturing process and continued to achieve much better frontiers.

Manifests traveled with mattresses at each step. The information on each manifest established fully the criteria of what each worker had to do to achieve a good outcome. Linking individual, customer orders to the end of production initiated a pull that extended upstream to external suppliers. Each batch of Kanban cards also had an unambiguous meaning. A batch of cards was the only way to specify the mix and volume of the next shipment and was sent for every order.

The example shows the JIT system at work. The process established the production rhythm for the entire plant by structuring information unambiguously between external customers and the plant, within the assembly line, between assembly and its feeder process-stages and between the feeder processes and their external suppliers.

13.10 JIT in Services

In spite of the natural differences manufacturing and service, there are possible applications and benefits of JIT techniques in service industries. In his pioneering article, Benson (1986) argues that "service operations are organised systems of production processes with the same potential of improvement through implementation of JIT precepts as manufacturing operations". In this context, service is an operation, producing a product. Even this product can not be inventoried; process of the production is similar to manufacturing.

In manufacturing organisations result of JIT application is a clear cut and measurable reduction of inventory and lead times. However, in service environments reduction of inventory may not be significant. Weiters states that financial justification of JIT in service industries is less likely but in service industries JIT offers intangible benefits in terms of improved service quality and customer satisfaction.

Example: Inman and Mehra observed the JIT in FedEx case. This package delivery company implements JIT to reduce their inventory of quasi-MRO goods (mainly packaging, labelling supplies). Program aims to reduce inventory but not as a primary objective. They aimed at improving their service quality and competitiveness through implementation of JIT and anticipated that inventories would be reduced as a result.

Based on this, they concluded that JIT application in service operations is beneficial but it should be carefully considered and planned before hand.

Benefits of JIT in Services

The following are the some of the ways in which JIT benefits can be achieved in a service firm:

1. Elimination of disruptions in work of the employees
2. Incorporating more flexibility in the service delivery system and training employees to handle more varied tasks
3. Reduction of the set-up time and costs
4. Elimination of service wastes including reduction of error and duplication of work
5. Minimization of work in progress.

A service firm may benefit from JIT system if it has the following:

1. The service operations are repetitive in nature like delivery of pizzas, carrying passengers from one place to another etc.
2. The service firm plays with high volumes
3. The service firm has tangible items to support the service like pizza in a pizza delivery system or seats, seat belt, magazines, food in an airplane etc.
4. The service firm involves manufacturing like operations.

JIT and Service Industry: An Overview

High quality in service delivery and service operations on a consistent basis: The employees can be taught the value of providing high quality, defect free services and make them realize that high quality in operations and resulting customer satisfaction is a definite order winner.

Uniform facility loading: The systems of reservation and the differences pricing are the ways to level off the load on the facility.

Standardization of working methodology: Higher efficiency in operations can be achieved by analyzing the work methods and adopting a standardised work methodology. However, it is possible usually in service operations which are highly repetitive in nature.

Notes

Close ties with the suppliers: Services that play with volumes like a fast food joint and mass merchandisers require close contact with the suppliers. Application of JIT, not only ensures more frequent shorter lead times but also the quality shipment of the supplies

Flexibility of the work force: Greater is the level of customization in the workforce, more will be the requirement for multi-skilled labor. There should be enough flexibility in the workforce to deal with different problems.

Example: An electronic repair shop needs wider experienced workforce to deal with the variety of equipments. They need skilled workforce to diagnose the problem correctly and then repair the defects.

Automation: This can play a major role in providing JIT services. Now-a-days we see the widespread network of ATMs which are a good example of JIT concept in services.

Preventive Maintenance: Services that are highly dependent on the use of machinery and components to effectively deliver the service should have good preventive maintenance system in place. It helps in providing services efficiently without any significant delay. Services like transportation requires mechanical modes of transportation and properly working spare parts etc.

Pull method of the flow of material: Service items where tangible items are processed like pizza outlet can reap in the benefits of pull factor.

Line flow strategy: The managers in the service system can easily recognise the employees and equipments under them and their capabilities. This helps in achieving a uniform flow throughout the system. It also helps eliminate wastage of employee's time.

Example: Banks use this method in faster processing of the Cheques.

Improvements in process and problem solving ability of the firm can contribute heavily in streamlining of the system: This results in higher customer satisfaction and greater employee productivity.

Simplification of the process, especially when customers take part in the system: The strategy is to simplify the system of operations and service delivery when customers themselves are involved in the process like in self service retail outlets, ATMs, Vending machines etc.

JIT in services, if achieved can be a major source of competitive advantage: This gives an edge to the service firms over other firms. This is their ability to provide services whenever required.

Case Study

Indian Detergent Market: Nirma vs HLL

Detergent Powder was introduced in India by the Soap & Detergent Division of Hindustan Lever Ltd. (HLL) in 1954, a subsidiary of Unilever. The division had two major products, 'Surf' detergent powder and 'Rin' washing soap. HLL viewed the products as middle class products. This was not a large market but HLL provided high quality products giving it a reasonable profit margin. Its product 'Surf' emerged as the market leader in detergent powder. 'Nirma' was established by Karsan Patel in Dec. 1969. Traditionally, clothes were washed by hand using hard yellow bars of laundry soap. Karsan Patel saw this as his market. This accounted for 95% of the detergent market.

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Nirma targeted this segment, producing cheap detergent powder that was easier to use compared to the laundry soap.

By 1977, Nirma had dented the detergent powder market with a market share of 12 percent compared to Surf's 31 percent. It continued to grow aggressively and between 1977 and 1984 Nirma's sales grew at a compound rate of 49 percent. By 1984, Nirma was selling 20,000 tonnes of detergent powder in comparison to HLL's 2000 tonnes. Within 15 years, it had become the one of the largest detergent powder brands in the world and was seriously challenging HLL's brand 'Surf'. Nirma was able to manufacture and distribute its product around 1/3rd the price of 'Surf'.

HLL's traditional approach was, 'think globally, act locally'. They had applied this philosophy to the detergent market. Initially, HLL management was of the view that "We can't make this detergent product. The Nirma powder is so different in quality, unit cost etc." They froze; in their minds there was no viable way to act except to wait for it all to blow over.

However, that did not happen. In 1986, Nirma introduced the Nirma bar, challenging HLL's other product 'Rin'. The quality difference between the two, Nirma bar and Rin, was limited but Nirma bar was sold at ₹ 1.50 for a 150 gm. cake which was 1/3rd the price of Rin. By 1989, the Nirma bar had a market share of 40 per cent. By 1992, Nirma had sales of 333,000 tonnes and had captured 55% market share.

The brand leader was finding pressure on its premium product, 'Surf.' Consumers were moving to lower price brands. To counter Nirma, HLL was unable to increase price of 'Surf' and had to put a lot of support below the line—its profit had eroded. It was losing its market of 'Rin'. The Soap & Detergent Division of Hindustan Levers was depending for its sustenance on 'Rin', as the margins of 'Surf' had shrunk. Nirma had hit the company at its soft spot and it was left with no option but to fight. It was forced to jettison its value creation logic and adopt an entirely new way of operating. It had to enter the low cost detergent market to stop the growth of Nirma.

They set up third party production in the states of Gujarat, Rajasthan, Uttar Pradesh, Punjab, Pondicherry, etc. These were called AFACON manufacturing units. HLL created 'Wheel'—a detergent powder that competed successfully with Nirma detergent powder. The Units were given conversion contracts. Raw Materials were supplied by HLL.

Initially, HLL tried to use its own distribution system to market the products. HLL had one of the strongest distribution networks in the country, but it did not deliver. Though HLL strengthened the network and the distribution system was highly motivated, yet it was very expensive. They still found this was not giving them enough margins to compete successfully.

The rest is history. HLL created Stefan Chemicals, a fully owned subsidiary. The responsibility of the AFACON manufacturing units was passed on to Stefan Chemicals. This finally was able to arrest the decline of HLL in this market. Initially, the manufacturing costs were 15 percent higher than Nirma's, but with a cost effectiveness program, HLL was able to help the AFCON units reach Nirma's costs. By 1991, Stefan Chemicals had 15 manufacturing units as compared to only 3 in the early 1980's. Ultimately Stefan Chemicals took over the marketing and distribution for Wheel. Stefan Chemicals successfully copied the structure used by Nirma. In 2004, Wheel' became the first Indian brand to exceed sales of ₹ 1,000 crores.

Questions

1. Compare Nirma's strategy vis-à-vis HLL's strategy.
2. Determine the role of SCM in success of HLL's detergents in India.

13.11 Summary

Notes

- Supply or material management activities focus on the upstream portion of the supply chain and are mainly concerned with suppliers and inbound logistics.
- 'Supply Chain Management' is defined as the integration-oriented skills required for providing competitive advantage to the organization that are basis for successful supply chains.
- Supply chain is an integral part of the value chain. The supply chain consists only of the primary activities or the operational part of the value chain. The supply chain, therefore, can be thought of as a subset of the value chain.
- Major elements in supply chain are: production, location, inventory, supply, transportation and information.
- Logistics focuses on the physical movement and storage of goods and materials. This involves evaluating and selecting various transportation options, developing and managing networks of warehouses when needed, and managing the physical flow of materials into and out of the organization.
- Logistics decisions are often tightly intertwined with production and inventory decisions, particularly when businesses must decide where to hold inventory in the supply chain.
- A critical part in supply chains that involve manufacturing is getting all the required parts and raw materials in the right sequence, the right quantity, the right quality and the right time to the manufacturing and assembly plants.
- Electronic Data Interchange (EDI) is the electronic exchange of business information– purchase orders, invoices, bills of lading, inventory data and various types of confirmations-between organizations or trading partners in standardized formats.
- E-commerce is usually defined as the conduct of business online, via the Internet. E-commerce means more choices, convenience and lower prices for consumers. It also provides new ways for businesses to grow and meet customer needs, and important benefits and cost-savings for governments and the people they serve.
- Supply chain management allows all the firms in a supply chain to look beyond their own objectives to the objective of maximizing the final customer's satisfaction.
- A firm in the supply chain must initiate the attempt to form partnerships and actively manage the supply chain. Often a firm that has a large amount of market power in the chain will become the leader of the supply chain.
- The SCOR model is based on a benchmarking process and used to measure the performance of an existing supply chain and its related processes.
- Supply chain management involves proactively managing the two-way movement and coordination (that is, the flows) of goods, services, information, and funds from raw material through end user.
- Supply Chain Design is a strategic decision. It reflects the structure of the supply chain over the next several years. It decides what the chain's configuration will be, how resources will be allocated, and what processes each stage will perform.
- A push/pull view of the supply chain is very useful when considering strategic decisions relating to supply chain design. This view forces a more global consideration of supply chain process as they relate to a customer order.

Notes

- Supply chain performance improves if all stages of the chain take actions that together increase total supply chain profits. A lack of co-ordination can impact the performance.
- Supply Chain Optimization is the application of processes and tools to ensure the optimal operation of a manufacturing and distribution supply chain.
- JIT is a management philosophy that strives to eliminate sources of manufacturing waste by producing the right part in the right place at the right time. Waste results from any activity that adds cost without adding value such as moving and storage.
- A Kanban system is a pull system, in which the Kanban is used to pull parts to the next production stage when they are needed; an MRP system (or any schedule based system) is a push system, in which a detailed production schedule for each part is used to push parts to the next production stage when scheduled.
- In spite of the natural differences manufacturing and service, there are possible applications and benefits of JIT techniques in service industries.

13.12 Keywords

E-banking: banking transaction carried out on the internet

E-commerce: defined as the conduct of business online, via the Internet

EDI: Electronic exchange of business information

EDIFACT: Electronic Data Interchange for Administration Commerce and Transport

External Supply Chain: It includes the key suppliers and customers, portion outside firm

FTP: File Transfer Protocol

Internal Supply Chain: The portion of a given supply chain that occurs within an individual organization

JIT: It strives to eliminate sources of manufacturing waste by producing the right part in the right place at the right time

Kanban: It is a visual aid to convey the message that action is required

Logistics: It focuses on the physical movement and storage of goods and materials

Pull View: It processes that are initiated by a customer order

Push View: It processes that are initiated and performed in anticipation of customer orders.

SCOR Model: It is based on a benchmarking process and used to measure the performance of an existing supply chain and its related processes

Supply Chain: This includes all the elements right from procurement of materials till end customer

Supply Chain Management: The active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage

VAN: Value Added Network

13.13 Self Assessment

Notes

State whether the following statements are true or false:

1. Supply chain excludes the transporters but includes the customers.
2. Value chain is greater than a supply chain and every one in the organisation may not be a part of supply chain but everyone is a part of value chain.
3. The effectiveness of storage management can be seen by the maximum amount of time the stock is locked inside the warehouse.
4. OTIS is one of the major manufacturers of elevators in India.
5. We can also refer to the internet as public EDI or opened EDI.
6. Payment of money by your ATM cum Debit card for any purchases made is termed as point of purchase transfer.
7. SCOR Model helps in comparing the organisation's performance to lower performing firms and find out the strengths.
8. The supplier of major raw material required to make goods is a part of internal supply chain.
9. Most of the FMCG companies adopt push method to carry forward the operations.
10. In processing Kanban is same as conveyance kanban.

Fill in the blanks:

11. Maruti Suzuki True Value shops are based on the concept of ....
12. .... is one of the major requirements for effective functioning of internal supply chain.
13. .... helps in tracking the inventory status without manual efforts and wastage of time.
14. .... accumulate demand from various enterprises to make a bulk order and receive price benefits from the suppliers.
15. One of the reasons for the benefits reaped from .... is because of the presence of servicescapes in service firms.

13.14 Review Questions

1. Discuss the macro level factors that necessitated the emergence of supply chain.
2. "The supply chain can be thought of as a subset of the value chain." Discuss.
3. Who all take part in a supply chain? How does a supply chain work? Explain with an example.
4. Write a short note on the importance of elements of supply chain.
5. "Logistics decisions are often tightly intertwined with production and inventory decisions". Why?
6. Do you think that there should be a balanced attention given to both inbound and outbound logistics? Justify your answer.
7. "EDI is a major cornerstone of e-commerce". Validate the statement.

Notes

8. "E-commerce is more than a business carried out on internet". Substantiate.
9. Critically analyse the emergence of e banking as a major way of transferring funds.
10. "The largest barrier to successfully managing a supply chain is perhaps the human element". Comment.
11. Critically analyse SCOR Model of Supply Chain.
12. "Supply Chain Design is a strategic decision". Elucidate.
13. How does the supply chain manage a two way movement and coordination? What do you understand by Supply Chain Orientation?
14. "JIT application in service operations is beneficial but it should be carefully considered and planned before hand." Elucidate.
15. Daimler Chrysler and General Motors vigorously compete with each other in many automobile and truck markets. When Jose Ignacio Lopez was vice-president of purchasing for GM, he made it very clear that his buyers were not to accept luncheon invitations from suppliers. Thomas Stalcamp, head of purchasing for Chrysler before the merger with Daimler, instructed his buyers to take suppliers to lunch. Rationalize these two directives in light of supply-chain design and management.
16. Can a supply chain be both efficient and responsive? Why or why not?
17. Describe the supply chain that might exist for a two-wheeler manufacturer and discuss the sort of information that might flow through the supply chain. How would this differ from that of a hotel?
18. Suppose you purchase a flashlight at Wal-Mart. The cash register reads the bar code price tag and reportedly within fourteen seconds, the Wal-Mart central warehouse is notified that the Wal-Mart retail store needs a new flashlight for the shelf to replenish the purchased item. Further, the manufacturer is also notified that the Wal-Mart central warehouse needs a new flashlight. Even the raw material suppliers are notified that the manufacturer now needs a little more raw materials (plastic housing, switch, light bulb, etc.), and so it goes - all the way up the supply chain. Analyse the process. Do you think Wal-Mart has a strong supply chain network? Is there any fault in their system?
19. How does just-in-time benefit the food and beverage industry? Explain their usage in context of fast food restaurants like McDonalds and Sub Way.

Answers: Self Assessment

1.	False	2.	True
3.	True	4.	True
5.	True	6.	True
7.	False	8.	False
9.	True	10.	False
11.	Reverse Logistics	12.	Communication Technology
13.	Automated Storage Retrieval System	14.	Aggregators
15.	Just-In-Time		

13.15 Further Readings

Books

N G Nair, *Production and Operations Management*

Stevenson, *Operations Management,* 8th Edition, Tata McGraw Hill

Upendra Kachru, *Production and Operations Management*, Excel Books, New Delhi

Online links

lcm.csa.iisc.ernet.in/scm/supply_chain_intro.html

tutor2u.net/business/production/just-in-time.html

www.exforsys.com/tutorials/supply-chain/scor-model.html

www.kanban.com

www.logisticsmgmt.com

Notes

Unit 14: Purchasing

CONTENTS

Objectives

After studying this unit, you will be able to:

- Explain purchasing interfaces
- Discuss the purchasing cycles
- Describe value analysis
- State centralized vs. decentralized purchasing
- Explain ethics in purchasing

Introduction

Purchasing is responsible for obtaining the materials, parts and supplies and services needed to produce a product or provide a service.

Notes

Did u know? Purchases represent about 55 percent of the cost of the finished product. This figure is typical for manufacturing firms. Labour constitutes about 10 percent, with the remainder being overhead expenses.

Because materials comprise such a large component of the sales, companies can reap large profits with a mall percentage reduction in the cost of materials. That is one reason why purchasing is a major component in supply-chain management as a key competitive weapon.

Though purchasing is a major constituent of the supply chain, it is also important that an organization have an integrated view of the elements within the supply chain. Are the policies and procedures used in purchasing consistent with those used in inventory control? Are the proper material-handling and control devices available for the type and quantity of material ordered and for the way the material is packaged? These are basic questions that have to be dealt by most organizations.

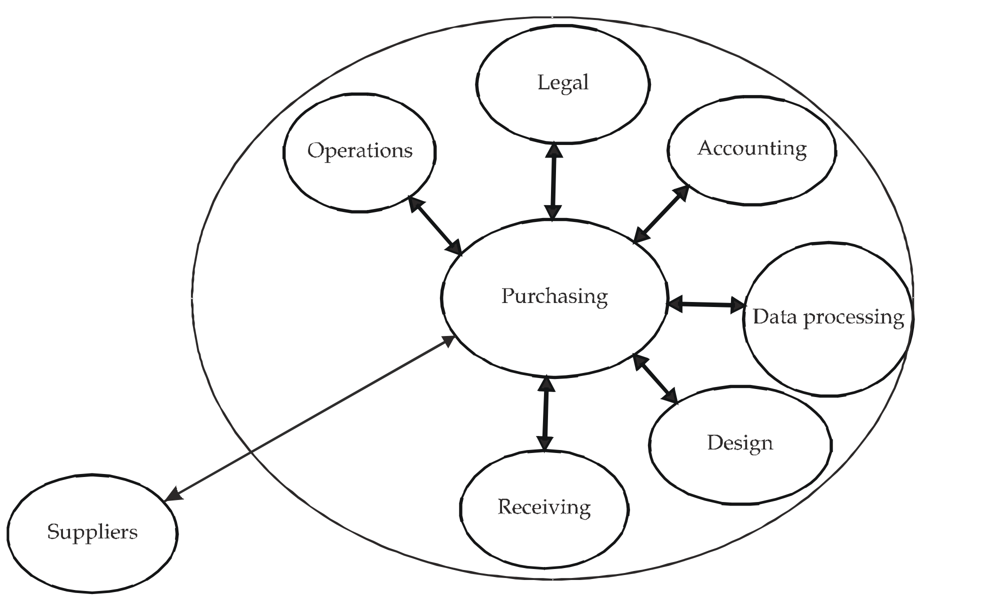
This is especially important as many organizations do not have an integrated supply chain function. The manager of purchasing, the materials manager, and the logistics manager, etc. may all report to different supervisors. This makes the co-ordination of policies and procedures and the integration of decisions difficult. Successful organizations devise innovative ways to integrate the elements of material management into the supply chain.

14.1 Purchasing Interfaces

The purchase department interacts with many departments within the organisation and it interacts with the suppliers which are external to the organisation. There is a two way interaction between various departments and purchasing function.

This is shown in the Figure 14.1 as given:

Figure 14.1: Purchasing Interfaces



Source: ocw.kfupm.edu.sa/user062%5COM2100102%5CPPT/Chap016.ppt

Notes

The first interface is with the operations department. The operations and production department sends the information about the requirements of materials, supplies, parts to the purchasing department and purchasing department places the order. Purchasing system keeps a track on the production and operation system so as ascertain the need for materials in advance and can keep required inventory.

The next interface is with the legal department. The purchase department has to sign a lot of deals and contracts with the suppliers and other concerned persons. The legal department also keeps an eye on the code of conduct and ethical practices of the purchasing officers.

The accounting department keeps a track of the vouchers and the bills of purchase. The accounting professionals are concerned with passing the bills and approving amounts for the required material.

Data processing department records all the required information of the purchase transactions. It also records the inventory levels and gives indication about level of inventory available form time to time. It also records information about the suppliers, transporters etc. All the information is collected in the data warehouse.

The design of the operations system would depend on the purchases made by the purchasing department and in it turn the design department takes care of the purchasing pattern and design. There also needs to be a frequency match between the design of the suppliers and the purchasing organisation.

All the purchases made are collected by the receipt department and then send for further cross checking by other departments. They check the bill of order and the voucher and collect the materials.

The most important interface, though, is with the suppliers. The purchasing department interacts the most with the suppliers and the suppliers interact with the purchasing personnel. All the dealings with the organisation are made as a result of the interaction between these tow entities.

Caselet

Fiat Sets up International Purchasing Office

– by Hindu News Bureau

Driven by cost advantage that countries such as India and China offer, the Italy-based Fiat Group announced setting up of an international purchasing office in New Delhi that can support its global production facilities in Europe, North America and Latin America. Through its purchasing office, Fiat will source components for different vehicles, including tractors, cars and commercial vehicles.

"We are sourcing auto parts worth €30 million at present from India and by 2010, our target is to increase the number to €50 million," said Mr Gianni Coda, Fiat Group Executive Committee Member & Chief Executive Officer for the Group's international purchasing operations.

Fiat began sourcing from China a year ago at a volume of €200-million worth of components in the first year. When asked if China was more competitive compared to India, Mr Coda replied, "There is not much difference. Both the countries roughly offer 12-15 per cent cost advantage. It is just that in some parts like glass, India has an advantage and in some cases, China scores higher."

Contd...

Notes

Sourcing Strategy

The company official explained that the reason for setting up its purchasing office now was mainly due to the integration of its worldwide sourcing operations from January this year in which Indian vendors were also being included. Fiat expects the strategy would be central in helping the group achieve its growth and margin expansion plan for 2007-2010 under which it plans to buy €8.5 billion of components from the 'best-cost countries', including India and China by 2010.

Mr Coda said that the components will be related to engine components - gears, axles, castings, glass in which India has a cost advantage.

"We have an engine plant in Poland that can produce 800,000 units. So there is a huge opportunity to supply engine parts there," he cited.

Fiat is already engaged with 50 suppliers in the domestic market for global sourcing. But, the company did not elaborate on the expansion plan of their supply base.

The international purchasing office would be headed by Mr Neeraj Hans with a team of 15 employees which is expected to grow to 50 by the year-end.

Source: thehindubusinessline.com

14.2 Purchasing Cycle

Purchasing can be both from the internal supply chain and the external supply chain, however, the purchasing department normally is associated with the external supply chain. Purchasing identifies, selects and evaluates potential suppliers, develops detailed specifications for the products or services needed by a firm, certifies the quality of supplier's goods and services, negotiates contractual terms and conditions, and develops long-term relationships with key suppliers. Sourcing activities ensure that the company has suitable sources for the goods and services it needs. In effect, purchasing activities link a firm with its upstream suppliers. Purchasing has a dual role, one is that of a buyer and the other is a facilitator and an external liaison with suppliers. The primary functions of purchasing are in the following areas:

1. Defining specifications for the purchased good or service
2. Developing criteria for supplier selection
3. Classifying suppliers according to performance
4. Evaluating the make or buy decision
5. Expediting and follow-up

14.2.1 Defining Specifications

Specifications for goods specify the physical dimensions of the part, tolerances that will allow the part to fit with other parts, strength and durability, size and shape and the required performance levels. Though setting these standards begins in design, purchasing should carry through to ensure that the acquired services or goods will do the job. The drawings and tolerances should be clearly defined and not subject to different interpretations.

In some cases, designers may specify tolerances that cannot be met or that can be met only with a significant increase in purchase price. The purchaser may have firsthand knowledge about possible alternatives that will cost less. Because this is often the case, input from the purchasing department in the early stages of product design can be useful and enhance the speed of product development and new product introduction.

Notes

Once the product is designed, purchasing has the following responsibilities:

1. To determine the availability of parts and material.
2. To collect up-to-date cost data that can be used to project the cost of producing the product in-house.
3. To judge whether the specifications can be met from the current list of suppliers.
4. To ensure that the specifications are consistent with accepted commercial standards and the material satisfies the purposes intended.

Purchasing manager may develop single or multiple sources for each required part. In buying services, the processes are similar. However, as physical units are not exchanged between supplier and customer, these transactions can sometimes become complex.

14.2.2 Developing Criteria for Supplier Selection

Three criteria most often considered by firms selecting new suppliers are price, quality, and delivery. The costs of poor quality can be high, particularly if defects are not detected until after considerable value has been added by subsequent operations. Shorter lead times and on-time delivery help the buying firm maintain acceptable customer service with fewer inventories.

A fourth criterion that is becoming very important in the selection of suppliers is environmental impact. This involves identifying, assessing, and managing the flow of environmental waste and finding ways to reduce it. In the not-too-distant future, suppliers who are environmentally conscious when designing and manufacturing their products will find this the most important criterion in their selection as suppliers.

14.2.3 Classifying Suppliers

Many organizations design formal programs to certify suppliers. With supplier certification, a supplier must be able to meet specific criteria. In many cases, a supplier has to receive certification before it can ship the first part.

Supplier certification typically involves site visits of a cross-functional team from the buying firm who do an in-depth evaluation of the supplier's capability to meet cost, quality, delivery, and flexibility targets from process and information system perspectives. Aspects of producing the materials or services are explored through observation of the processes in action and review of documentation.

ISO (International Standards Organization) 9000 is a set of standards that suppliers need to satisfy to compete in the global marketplace. Certification programs can be established under a variety of circumstances. Where a supplier is the sole source for the part, certification should be mandatory, and a close and cooperative working relationship needs to exist between the customer and its supplier.

Whether or not an organization has a certification program, a supplier's performance should be monitored regularly. The performance review should be held with the supplier and, if possible, supplemented by notifying the supplier every time there is a violation of the criteria so that corrective action can be taken.

Another reason for informing suppliers about mistakes is that the importance of product quality and delivery date requirements are reinforced in the mind of the supplier.

14.2.4 Evaluating the Make or Buy Decision

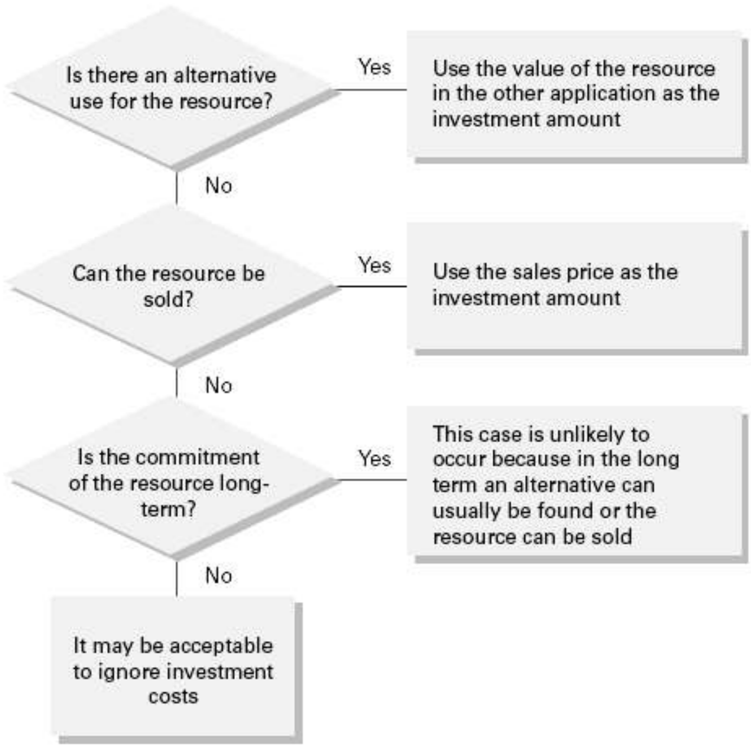
In the build-up of a product or service, there are some parts that the organization will create internally, some parts, it may have no option but to purchase from outside, the other remaining parts can be either made internally or purchased from suppliers. To decide whether a service or good should be provided from inside the organization or it is to be purchased from suppliers, management must ask the following questions:

1. Who has the technical capabilities to provide the good or service?
2. Who can deliver a quality product?
3. Who can make timely deliveries?
4. What costs are associated with each alternative?

A make or buy decision should be viewed as an investment decision. Very often, new equipment or balancing equipment is required to manufacture the part in-house. Figure 14.2 provides a framework of how such costs can be treated. Management should consider internal sources for services or goods and evaluate these sources to the external sources with the same after thorough analysis. One should be careful that there are no hidden costs when evaluating alternatives. Internal sources should perform at the same high level expected from external suppliers.

The real cost of a purchased product is not the unit price, but the lowest final cost, which is the lowest total cost to the buying firm. The lowest total cost includes the purchase price, transportation and receiving costs, costs to rework defective products, and costs for special processing that would not be necessary if another supplier were used. The lowest-final-cost objective relies on the system view of the firm.

Figure 14.2: Investment for Make or Buy Decision



Notes

Technology, Quality, and Timely Delivery: Any make or buy decision should take into account considerations other than the economic factors. What technology is being used by the potential supply sources? Better technology generally results in lower rejections and long-term cost savings. What is the quality of the management? Do they meet the minimum requirements for the job?

In addition, quality and delivery need to be integrated with the economic analysis when deciding whether to make or to buy. Such qualitative factors need to be given weightage. These decisions require judgment and are often subjective. However, a careful analysis of the opportunity costs due to failure of performance has to be worked out to reach a good decision.

14.2.5 Expediting and Follow-up

Expediting is the monitoring of supplier deliveries of materials that in some way have become critical for the customer.

Example: Production schedulers may have forgotten to order floppy disk drives, and now they are needed quickly. Inventory records may overstate the number of hair pins available. The supplier may not have met the delivery date for some reason. Expediters phone suppliers to talk about the importance of an order. They plead with and threaten suppliers to get their order moved up in line for fast delivery.

Expediting is usually caused by a failure of the organization or its suppliers. Efforts should be made to solve the problem by eliminating the source of the problem, rather than by relying on expediting. Eliminating the source of the problem involves better supplier selection and improved control of purchasing functions. A well-run purchasing operation should strive to eliminate expediting by making suppliers responsive to the organization's needs.

Follow-up and Evaluation

As part of an organization's supplier certification program, the purchasing department should collect and maintain information about each supplier. This information should be used to evaluate performance and to determine the future acceptability of all suppliers. In addition, both positive and negative information should be given as feedback to all suppliers. Suppliers who are doing a good job should be positively reinforced. Suppliers who are not performing well may not fully understand the importance of their performance to the customer's organization. These poorly performing suppliers may not even be aware of the extent of their shortcomings. Clear and immediate feedback may help them improve.

14.2.6 Procurement Cycle

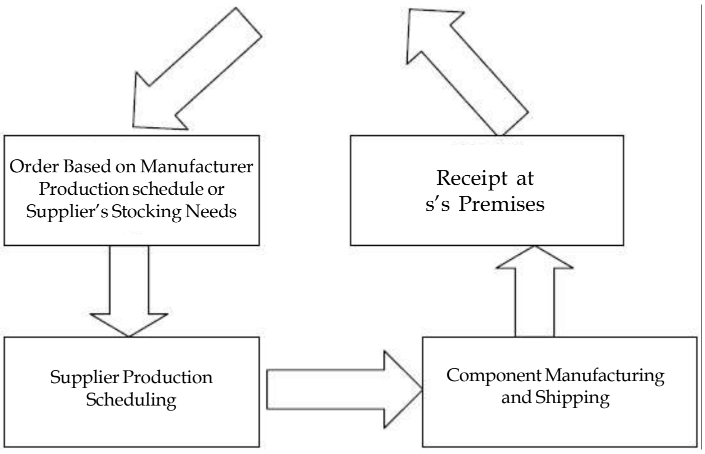
The procurement cycle occurs at the manufacturer/supplier interface and includes all processes necessary to ensure that materials are available for manufacturing to occur according to schedule.

The procurement cycle begins when the manufacturer orders components from suppliers to replenish the component inventories. The relationship is quite similar to the other cycles with one significant difference. Whereas retailer/distributor or customer/retailer orders are triggered by uncertain customer demand, component orders can be determined precisely if lead times are not very large.

Component orders depend on the production schedule and the manufacturer decides what the production schedule will be by the distributor order and current product availability in the manufacturer's finished-goods warehouse. Suppliers are linked to the manufacturer's production schedule and can plan supply based on this information. Where the supplier has a large lead time, the supplier produces to forecast because the manufacturer's production schedule may not be fixed that far in advance.

In practice, there may be several tiers of suppliers, each producing a component for the next tier. A similar cycle would then flow back from onstage to the next. The processes in the procurement cycle are shown in Figure 14.3.

Figure 14.3: The Procurement Cycle



Task Visit any one businessman in your locality and find out about the purchasing cycles of different products.

14.3 Value Analysis

Value Analysis in purchasing refers to the examination of each procurement item to ascertain its total cost of acquisition, maintenance, and usage over its useful life and, wherever feasible, to replace it with a more cost effective substitute. It is sometimes also called value-in-use analysis.

The basic premise of value/engineering analysis is that it an individual, or team, can identify potentials for efficiency gains.

During the last few years purchasing and supply management, along with most other areas of organizational activity, have evolved from a process (how many purchase orders were processed) to a strategic (how can our organization achieve meaningful differentiation, low cost, or both) orientation. This means:

1. Make-or-outsource decisions may be driven more by access to world-class technology than by shaving a few percentage points off cost. A key issue here is likely to be whether the activity is core to the organization. Core competencies will tend not to be out-sourced (regardless of the "economics") while peripheral activities may be actively outsourced so that the organization can focus its efforts on core activities.

2. Lease-or-buy decisions have evolved from identifying the best financial options to gaining access to appropriate technology under favorable financial arrangements.

Notes

Example: Obtaining a better price for a longer commitment might be offset by being locked into obsolescent technology during the term of the lease.

Similarly, a decision to buy might lock an organization into equipment that is difficult to replace when it becomes obsolete.

3. Supplier involvement in product and process development has become increasingly important. This means that purchasing and supply management must become involved in new product and processes development programs at (or before) the idea stage. In addition, purchasing and other areas of the organization must be skilled at integrating the development efforts of multiple suppliers to develop competitive products, and improved production and administrative processes, on time and within budget.
4. Finally, cost avoidance/reduction opportunities must increasingly be coordinated among external and internal customers, other interested organizational departments, and suppliers throughout the supply chain (or the supply web).

The application of value analysis/engineering techniques to products and services has long been recognized. However, these techniques are equally important to administrative processes. This is especially important to supply management professionals because much of what we do is manage administrative processes.

Notes According to the Wall Street Journal (October 6, 2004, page A-1), General Motors wants to reduce the types of radios in its cars worldwide from 270 to 50 for a 40% savings. Other examples of savings in tangible products include rationalization of MRO (work gloves, lubricants, and repair parts), substituting one material for another to reduce the total costs of manufacturing, finishing, packaging, distribution, returns, and warrantee claims.

Administrative processes have not received much attention from value analysis/engineering advocates. Purchasing and supply professionals develop, coordinate, and participate in a wide range of administrative processes. They include supplier identification and qualification, developing and administering RFPs and contracts, monitoring supplier performance, negotiating internally and externally, and developing and implementing buying procedures and policies. During the 1990s purchasing underwent a revolution in procedures. The "traditional purchasing cycle (receive a requisition, selecting a supplier, issuing a purchase order, follow-up and expediting, reconciling the purchase order with receiving, and authorizing the invoice for payment) evolved into programs of p-cards, systems contracts, annual contracts, and electronic ordering. Other purchasing and supply management processes lend themselves to value analysis/engineering techniques. They include monitoring of supplier performance, monitoring supplier financial health, development of specifications and statements of work, supplier qualification, development of negotiation strategies, and the development and management of supplier agreements.

14.3.1 Value Analysis Method

In all problem solving techniques, we are trying to change a condition by means of a solution that is unique and relevant. If we describe in detail what we are trying to accomplish, we tend to describe a solution and miss the opportunity to engage in divergent thinking about other alternatives. When trying to describe problems that affect us, we become locked in to a course of action without realizing it, because of our own bias. Conversely, the more abstractly we can define the function of what we are trying to accomplish, the more opportunities we will have for divergent thinking.

This high level of abstraction can be achieved by describing what is to be accomplished with a verb and a noun. In this discipline, the verb answers the question, "What is to be done?" or, "What is it to do?" The verb defines the required action. The noun answers the question, "What is it being done to?" The noun tells what is acted upon. Identifying the function by a verb-noun is not as simple a matter as it appears.

Identifying the function in the broadest possible terms provides the greatest potential for divergent thinking because it gives the greatest freedom for creatively developing alternatives. A function should be identified as to what is to be accomplished by a solution and not how it is to be accomplished. How the function is identified determines the scope, or range of solutions that can be considered.

That functions designated as "basic" represent the operative function of the item or product and must be maintained and protected. Determining the basic function of single components can be relatively simple. By definition then, functions designated as "basic" will not change, but the way those functions are implemented is open to innovative speculation.

As important as the basic function is to the success of any product, the cost to perform that function is inversely proportional to its importance. This is not an absolute rule, but rather an observation of the consumer products market. Few people purchase consumer products based on performance or the lowest cost of basic functions alone. When purchasing a product it is assumed that the basic function is operative. The customer's attention is then directed to those visible secondary support functions, or product features, which determine the worth of the product. From a product design point of view, products that are perceived to have high value first address the basic function's performance and stress the achievement of all of the performance attributes. Once the basic functions are satisfied, the designer's then address the secondary functions necessary to attract customers. Secondary functions are incorporated in the product as features to support and enhance the basic function and help sell the product. The elimination of secondary functions that are not very important to the customer will reduce product cost and increase value without detracting from the worth of the product.

The cost contribution of the basic function does not, by itself, establish the value of the product. Few products are sold on the basis of their basic function alone. If this were so, the market for "no name" brands would be more popular than it is today. Although the cost contribution of the basic function is relatively small, its loss will cause the loss of the market value of the product.

One objective of value analysis or function analysis, to improve value by reducing the cost-function relationship of a product, is achieved by eliminating or combining as many secondary functions as possible.

14.3.2 Value Analysis Process

The first step in the value analysis process is to define the problem and its scope. Once this is done, the functions of the product and its items are derived. These functions are classified into "basic" and "secondary" functions. A Cost Function Matrix or Value Analysis Matrix is prepared to identify the cost of providing each function by associating the function with a mechanism or component part of a product. Product functions with a high cost-function ratio are identified as opportunities for further investigation and improvement. Improvement opportunities are then brainstormed, analyzed, and selected.

Notes

The objective of the Function Cost Matrix approach is to draw the attention of the analysts away from the cost of components and focus their attention on the cost contribution of the functions. The Function Cost Matrix displays the components of the product, and the cost of those components, along the left vertical side of the graph. The top horizontal legend contains the functions performed by those components. Each component is then examined to determine how many functions that component performs, and the cost contributions of those functions.

Detailed cost estimates become more important following function analysis, when evaluating value improvement proposals. The total cost and percent contribution of the functions of the item under study will guide the team, or analyst, in selecting which functions to select for value improvement analysis.

A variation of the Function-Cost Matrix is the Value Analysis Matrix. This matrix was derived from the Quality Function Deployment (QFD) methodology. It is more powerful in two ways. First, it associates functions back to customer needs or requirements. In doing this, it carries forward an importance rating to associate with these functions based on the original customer needs or requirements. Functions are then related to mechanisms, the same as with the Function-Cost Matrix. Mechanisms are related to functions as either strongly, moderately or weakly supporting the given function. This relationship is noted with the standard QFD relationship symbols. The associated weighting factor is multiplied by customer or function importance and each columns value is added.

These totals are normalized to calculate each mechanism's relative weight in satisfying the designated functions. This is where the second difference with the Function-Cost Matrix arises. This mechanism weight can then be used as the basis to allocate the overall item or product cost. The mechanism target costs can be compared with the actual or estimated costs to see where costs are out of line with the value of that mechanism as derived from customer requirements and function analysis.

14.3.3 Importance of Value Analysis

Implemented diligently, value analysis can result in:

1. reduced material use and cost
2. reduced distribution costs
3. reduced waste
4. improved profit margins
5. increased customer satisfaction
6. increased employee morale

14.4 Centralized vs Decentralized Purchasing

There are many ways to run a purchasing department. What business functions are included is one. Some companies include various material management responsibilities, inventory control, warehouse and logistics in the one department. In larger companies you might find all of these functions as separate departments. The major question is always whether to be centralized or decentralized. This is usually a decision of top management, Chief Purchasing Officer, Director of Purchasing or possibly the Chief Executive Officer or owner. There is no magic formula to determine which way is the best.

Notes

Centralized purchasing means buying and managing purchases from one location for all locations within an organization. This can also be run by a central location buying in to distribution warehouse that feeds smaller warehouses. This is called a hub and spoke system.

In other words, it is the control by a central department of all the purchasing undertaken within an organization. In a large organization centralized purchasing is often located in the headquarters. Centralization has the advantages of reducing duplication of effort, pooling volume purchases for discounts, enabling more effective inventory control, consolidating transport loads to achieve lower costs, increasing skills development in purchasing personnel, and enhancing relationships with suppliers.

Decentralized is the opposite where each plant or office buys what it needs. This operation allows any employee to buy what he needs. You can also run this operation with a designated buyer assigned to the site to do the buying.

The more decentralized an operation is, the less control the home office has. You have a duplication of effort in buying and less buyer specialization. You lose discounts on quantity buys. You lose freight options based on dollars or weight. Also some support is lost from the supplier as there is no single contact for the supplier to deal with. Volume buying may not be calculated for all your sites.

Advocates of decentralization claim that local management has the incentive to control cost when the local operation is set up as a profit center. Many companies operate with a mixed system. The central operation may buy major commodities but allow local operations to buy all MRO supplies.

It is difficult to change from decentralized purchasing to centralized purchasing. Employees feel their privileges are being taken away. They feel they are losing control of their site. Some will refuse to really cooperate in the changes in hopes to making the program look unsuccessful.

Task List some organisations that have a decentralized purchasing system.

14.5 Ethics in Purchasing

There are several codes of conduct that is followed all around the world. The general ethics in purchasing involves:

1. Give first consideration to the objectives and policies of the institution that you are working for.
2. Strive to obtain the maximum value for each penny of expenditure.
3. Decline personal gifts or gratuities.
4. Grant all competitive suppliers equal consideration insofar as state or federal statute and institutional policy permit
5. Conduct business with potential and current suppliers in an atmosphere of good faith, devoid of intentional misrepresentation.
6. Demand honesty in sales representation whether offered through the medium of a verbal or written statement, an advertisement, or a sample of the product.
7. Receive consent of original or of proprietary ideas and designs before using them for competitive purchasing purposes.

Notes

8. Make every reasonable effort to negotiate an equitable and mutually agreeable settlement of any controversy with a supplier; and/or be willing to submit any major controversies to arbitration or other third-party review, in-so-far as the established policies of my institution permit.
9. Accord a prompt and courteous reception insofar as conditions permit to all who call on legitimate business missions.
10. Cooperate with trade, industrial and professional associations, and with governmental and private agencies for the purposes of promoting and developing sound business methods.
11. Foster fair, ethical and legal trade practices.
12. Counsel and cooperate with department members and promote a spirit of unity and a keen interest in professional growth among them.

Case Study

Centralized Purchasing Pays off for Radisson

There are a lot of benefits that accrue from centralizing purchasing, as several hotel chains have recently discovered. But none has been attempting it on the scale of Carlson Cos. Carlson is combining the purchasing for its Radisson Hotel chain, Colony Resort Hotels, TGI Friday's restaurant chain and the Country Kitchen restaurant chain into one central group and it's been paying off.

Marvin Salsbury, vice president of purchasing and distribution for the Carlson Hospitality Group, has been ramrodding the conversion from its original concept. It started with TGI Friday's and worked so well that last year plans were implemented to apply the plan across all of the Carlson properties in one area, the Southeast.

Now, a little over a year later, the concept has proven itself and is being moved nationwide, one region at a time, according to Salsbury. At the present time there are 71 Radisson Hotels and eight Colony Resorts using the system, and within the next six weeks, 12 to 15 more units will be added. Salsbury says that includes three Radissons of the Paraiso Hotels group in Mexico City, with two others in that country to be added later.

What are the advantages of centralizing purchases? Volume leverage is the obvious one, Salsbury says. But there are others. "It reduces deliveries and increases drop size, which means less billing and less staffing needed to receive goods."

Centralizing has reduced foods costs, in part because it lets the company take advantage of promotional and other allowances. All of the savings are passed right through to operations, including franchisees, Salsbury emphasizes.

The use of one national, multi facility distributor simplifies the chain of supply, he points out. Furthermore, it enables Carlson to standardize products. And it frees hotel purchasing personnel to concentrate on expediting and quality control instead of spending all their time on "shopping," Salsbury explains.

"They already had the experience of negotiating for major contracts. Now they have the additional voluve leverage to be even more effective."

Contd...

Notes

How does centralizing purchasing affect hotel buyers?

"For the better," Salsbury reports. "Instead of spending most of their time on the phone or seeing sales reps and shopping for price, they are freed to manage their inventories better. They are able to concentrate on optimizing deliveries.

"Under the old system, they had to constantly search for the best value at the best price. That takes up a lot of time that is now spent in managing the purchasing function.

"The value under our central program is controlled by the specifications. We have established those standards in conjunction with the people out there in the properties. By using a single distributor and auditing our results, we're assured we're getting what we specify.

"The hotel buyer can be sure that he or she is getting the best value obtainable, because we have a combined leverage that never existed at the single-property level."

Salsbury insists that just getting a lower price isn't the objective. "It's a secondary benefit," he says. "Our main objective is to make the purchasing function more quality efficient. We want to take the guesswork out of buying foods and other supplies.

"For example, there may be three different olives with the same counts on the label. Yet, when you cut those products, you find that the yields may be widely different. You often find that the most olives that are the most costly by the unit are really the most economical when you relate them to yield."

And, says Salsbury, "the savings also represent the allowances related to distribution efficiencies. That's all new money, since there was no system in place to get these efficiencies before we installed the program."

Is the program proceeding according to schedule?

"In fact," Salsbury says, "it's ahead of schedule. We've been able to put it in place faster that we had forecast because of the wholehearted cooperation we'e gotten from the local level. One of the keys to the whole thing is keeping it invisible to the people we're really serving: the chefs and food and beverage managers. They can call for their orders just as they did before, but now it works with more efficiency at lower cost.

"We're making sure that we put each region on line and work all the bugs out before we tackle the next one. We not only make sure the program is working; John [McDonald] tracks it to see that it is doing what we intended. By this time next year, we should have all of our properties under the program and taking advantage of the effeciencies and savings."

Questions

1. What are Salsbury's thoughts on centralized purchasing?
2. What benefits does the company want to avail by centralized purchasing?

Source: http://findarticles.com/p/articles/mi_m3190/is_n45_v24/ai_9116104/?tag=content;col1

14.6 Summary

- Purchasing is responsible for obtaining the materials, parts and supplies and services needed to produce a product or provide a service. Purchases represent about 55 percent of the cost of the finished product.

Notes

- Though purchasing is a major constituent of the supply chain, it is also important that an organization have an integrated view of the elements within the supply chain.
- The purchase department interacts with many departments within the organisation and it interacts with the suppliers which are external to the organisation. There is a two way interaction between various departments and purchasing function.
- Purchasing can be both from the internal supply chain and the external supply chain, however, the purchasing department normally is associated with the external supply chain.
- Purchasing identifies, selects and evaluates potential suppliers, develops detailed specifications for the products or services needed by a firm, certifies the quality of supplier's goods and services, negotiates contractual terms and conditions, and develops long-term relationships with key suppliers.
- The procurement cycle occurs at the manufacturer/supplier interface and includes all processes necessary to ensure that materials are available for manufacturing to occur according to schedule.
- Value Analysis in purchasing refers to the examination of each procurement item to ascertain its total cost of acquisition, maintenance, and usage over its useful life and, wherever feasible, to replace it with a more cost effective substitute. It is sometimes also called value-in-use analysis.
- Centralized purchasing means buying and managing purchases from one location for all locations within an organization. This can also be run by a central location buying in to distribution warehouse that feeds smaller warehouses. This is called a hub and spoke system.
- Decentralized operation allows any employee to buy what he needs. You can also run this operation with a designated buyer assigned to the site to do the buying.
- The purchasing professionals all over the world are required to follow certain code of ethics so that they prove to be an asset for the company and take the company to new heights.

14.7 Keywords

Centralized Purchasing: Buying and managing purchases from one location for all locations within an organization.

Decentralized Purchasing: It allows any employee to buy what he needs

Expediting: Monitoring of supplier deliveries of materials that in some way have become critical for the customer.

ISO: International Standards Organisation

Procurement Cycle: It occurs at the manufacturer/supplier interface and includes all processes necessary to ensure that materials are available for manufacturing

Purchasing: It is responsible for obtaining the materials, parts and supplies and services needed to produce a product or provide a service

Purchasing Cycle: The process of purchasing materials

Purchasing Interfaces: Interaction of the purchasing and other aspects of the firm like legal, operations etc.

QFD: Quality Function Deployment

Value Analysis: Examination of each procurement item to ascertain its total cost of acquisition, maintenance, and usage over its useful life.

14.8 Self Assessment

State whether the following statements are true or false:

1. About 30 percent of the total production costs are incurred as overhead costs.
2. There is a two way interaction between purchasing and other departments within the organisation but one way interaction with the seller.
3. It is the not the responsibility of the purchasing department to check the levels of inventory.
4. The purchasing department has a major role to play right form the ideation stage of new product development.
5. The value analysis largely plays on the quality value relationship.
6. It is very convenient for any firm to switch from one type of purchasing system to another.
7. All the suppliers should be granted equal considerations irrespective of the size of order.

Fill in the blanks:

8. The way to solve problem of different reporting procedures of the employees of different departments is ....
9. Purchasing and legal department have a .... interaction.
10. In most of the organisation purchasing has a .... role to play.
11. Suppliers need .... to put forward their candidature on the global business scene.
12. In organisation where .... purchasing is done, corporate offices have less control over branch offices.

14.9 Review Questions

1. "Purchasing is a key competitive weapon". Discuss
2. Why are purchasing decisions so important in an organisation? Discuss its importance in supply chain management.
3. Explain the two way interaction between purchasing and other departments. Can there be a one way interaction also?
4. How can purchasing be from internal supply chain? What is the importance of such type of a supply chain?
5. "Purchasing has a dual role to play in an organisation". Substantiate.
6. Explain the importance of supplier monitoring. Determine the role of supplier in purchasing.
7. "A make or buy decision should be viewed as an investment decision" Explain the rationale behind the statement.

Notes

8. How is value analysis related to efficiency gains? What importance does value analysis hold in an organisation?

9. "The cost to perform a function is inversely proportional to its importance". Elucidate.

10. Write short notes on: Cost Function Matrix and Quality Function Deployment.

11. Compare and contrast centralized and decentralized purchasing systems.

12. Why do you think it is difficult to move from a decentralized purchasing system to a centralized one?

13. Assume a firm has prepared the following cost estimates for the manufacture of a subassembly component based on an annual production of 8000 units:

	Per Unit	Total
Direct Materials	$5	$40,000
Direct labour	4	32,000
Variable overhead applied	4	32,000
Fixed overhead applied (150% of direct labour cost)	6	48,000
Total cost	$19	$152,000

The supplier has offered the subassembly at a price of $16 each. Two-thirds of fixed factory overhead, which represents executive salaries, rent, depreciation, and taxes, continue regardless of the decision. Should the company buy or make the product?

14. Suppose you are the purchasing officer in an organisation that in engaged in apparels production. Your management wants that purchasing should be centralized but employees in your department resist working under this condition. How will you handle the situation?

14. What are the codes of conduct that you think a purchasing department should adhere to? Should a purchasing officer purchase a low quality raw material because it is cost effective and approved by the management? If not, then what should he do?

16. ABC company has the following manufacturing costs for producing 120 units of part X:

Direct materials	28,000
Direct labor	18,500
Mixed overhead	29,000
Variable overhead	15,000
Fixed overhead	30,000
Total	₹120,500

If it considers buying the part, 80 units of parts would cost ₹ 90000. Should the company make or buy the part?

Answers: Self Assessment

1. True
2. False
3. False
4. True
5. True
6. False
7. True
8. Supply Chain
9. Two Way
10. Dual
11. ISO 9000
12. Decentralized

14.10 Further Readings

Notes

Books

Upendra Kachru, *Productions and Operations Management*, Excel Books, New Delhi.

Everest E Adam & Albert, *Productions and Operations Management*, IVth Ed, PHI Publications.

Joseph G. Monks, *Operations Management (Theory & Problems)*, McGraw Hill Intl.

Online links

fac-staff.seattleu.edu/.../purchase%20ordering%20cycle%20-%20OH.doc

www.cbelearn.ca/joint/Purch1/13s3steps.htm

www.npd-solutions.com/va.html

www.mtholyoke.edu/offices/fs/purchasing/ethics.shtml

www.purchasing.com/.../13053-Centralized_vs_Decentralized_Purchasing

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