LOVELY PROFESSIONAL UNIVERSITY

PRODUCTION AND OPERATIONS MANAGEMENT

Edited By

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SYLLABUS

Production and Operations Management

Objectives: 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.

Sr. No.	Topics
1.	Classification of Decision Areas in OM, Brief History, Operations Strategy, Flexibility, Modern vs. Traditional Approach.
2.	Services and Their Characteristics, Service Matrix, Service Quality, Role of services in Economy.
3.	**Quality Control :** What is Quality , Statistical process Control , Control Charts X Charts , R Charts, P charts , C charts
4.	**Quality Management:** Acceptance Sampling, Cost of Quality, Total Quality Management, History of TQM, Quality Gurus: Deming, Juran and Ishikawa, Quality Circles, Zero Defect Concept, Service Quality Model. Six Sigma
5.	**Productivity:** Various kinds of productivity measures, Multifactor productivity, Efficiency and effectiveness. Business Process Reengineering, Bench Marking. Pursuit of Excellence in Organisations , TATA Business Excellency Model
6.	**Supply Chain Management:** Purchasing, Value Analysis/ Value Engineering, Vendor Relations. Learning Curve , Forward Buying , Make or Buy Decisions
7.	**Inventory Model & Safety Stocks:** Optimal Order Quantity, EOQ, Economic Batch Quantity. ABC Analysis , VED Analysis
8.	**Building of a supply chain:** orientation & Implementation of Supply Chain functions within an organisation , Single Source vs Multiple Sources
9.	**Spatial Decisions:** Plant Layout. Basic Types of Layouts and their merits & demerits. Optimisation in process layouts. Use of Schematic Diagrams and software to solve layout problems. Applications in service Industries. Introduction to Cellular Manufacturing and Group Technology. Location and factors affecting a location
10.	**Timing Decisions:** Production Planning and Control. Importance of time Horizon, Dovetailing of Plans, Production control, Assembly line Balancing. Scheduling. Shop loading & Index method

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Unit 1: Operations Management Basics

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Objectives

After studying this unit, you will be able to:

- Recognize the meaning and scope of operations management;
- Describe the historical background of operations management;
- Explain the interrelationship of operations management with different functions;
- Discuss the role of operations manager.

Introduction

Operations Management concentrates on the core businesses, squeezes out the waste, and focuses on differentiating between competitors in meaningful ways. The importance of Operations Management lies in examining the processes by which goods and services are created and to use the available knowledge and techniques to resolve problems. It has to think and rethink, whether the practices adopted are still appropriate today. And, if not, what new techniques and methodologies should replace them?

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In fast clock speed industries, the focus of operations management is on the structural components of the discipline, i.e. product design, process, capacity and location. In slow clock-speed industries the focus of the discipline is on the infrastructural components, i.e., quality, manufacture, outsourcing, planning and other components of the transformation process.

The success of Operations Management can be measured by its ability in creating world class companies.

Example: In moderate clock-speed industries, Bajaj Auto has focused on Operations Management to emerge as lowest cost manufacturer of two-wheelers in the world. Reliance Industries leads worldwide in project management. In slow clock-speed industries, Tata Steel is the lowest cost steel producer, internationally. Infosys, Tata Consultancy Services and Wipro have established their superiority over their international rivals in fast clock-speed products like software.

1.1 Historical Background

A leisurely cruise through the history of any subject offers the reader a historical perspective and an opportunity at reflection. Tracking the changing concepts of the subject, and what it has been at different points in time, also helps in identifying patterns in the development of ideas. Most important, I hope, an understanding of history should foster the ability to sort through the barrage of ideas – some good and some not so good – about the subject.

Operations Management has been variously known as Industrial Management, Management Science/Operations Research, Production Management, and Production and Operations Management.

The concepts associated with Operations Management, perhaps, have their roots embedded in the development of early organizations. The class of problems represented by Operations Management came into high relief in the era after the Industrial Revolution. This was a period of radical changes. People got replaced by machines, and water and mule power replaced human muscular effort. These developments changed the nature of production. As production moved from the cottage to the factory, the seeds of operations management spouted on fertile ground.

1.1.1 Scientific Management – Time and Motion Studies

In 1769, James Watt applied for the patent of the steam engine. By 1785, the steam engine was being manufactured and used. In 1799, Eli Whitney began mass production and introduced the concept of standard interchangeable parts. By the late 1700s, this had resulted in the development of the machine tool industry – metal tools and machines that built the parts of other machines or goods became available. Many organizations evolved into large, vertically integrated businesses. Managers of organizations faced coordination problems of unprecedented scope.

Treatises on organizing, measuring, and managing production in these challenging settings were published. Frederick Winslow Taylor enunciated his theory of "scientific management" in the late 19th and early 20th centuries. The basis of "scientific management" was a focus on machines and the system of their utilization. It was based on Taylor's postulations:

1. Scientific laws govern work, so scientific methods can be used to analyze work.
2. Workers are different, so match workers to their job and then train them thoroughly.
3. Use employee self-interest to motivate.
4. Separate the responsibilities of workers and managers.

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The concept of Scientific Management led to the development of 'time and motion study'. The first contribution in this direction was made by Taylor in the 1880s. Early in the 20th century, Frank and Lillian Gilbreth developed a more systematic and sophisticated method of 'time and motion study', taking into account the limits of human physical and mental capacity and the importance of a good physical environment.

Time and motion study is an analysis of the operations required to manufacture an article in a factory, with the aim of increasing efficiency. Each operation is studied minutely and analyzed in order to eliminate unnecessary motions and thus reduce production time and raise output, which increases productivity.

In the early 1900s, Alfred P. Sloan of General Motors introduced the concept of 'organizational management' and Henry Ford introduced 'assembly-line manufacturing'. The Hawthorne Studies by Elton Mayo, in 1927, resulted in the Human Resources Movement. These developments changed the way operations were managed in many businesses, during this period.

1.1.2 World War II to the 1960's – Operations Research

Before World War II the focus of 'scientific management' was based on the micro-environment in the manufacturing sector. During the War, the focus moved from the micro-environment to the macro-environment.

A new multi-disciplinary approach to problem solving, called Operations Research, was developed. This was a quantitative approach basically concerned with the efficient allocation and control of resources. Multi-disciplinary operations research groups, largely initiated and founded by government and quasi-governmental organizations, were formed.

These groups focused on developing algorithms and methodologies to solve optimization problems that arose in a broad range of functional areas. They successfully developed models on linear programming, network flow problems, inventory theory, dynamic programming, machine maintenance, queuing and game theory, etc., to identify how operations could be improved.

Example: While Dantzig applied linear programming to the travelling salesman problem; Clark, Scarf, etc., developed models on inventory theory and so on.

The Ford Harris Economic Order Quantity model, however, dates as far back as 1915. These early successes resulted in the birth of operations research groups at many business organizations which were formed with the objective of finding ways of improving performance.

During the late 1960s, business schools began to take interest in the more scientific and rigorous approaches advocated by operations research groups for decision making and incorporated this discipline in business curricula.

Notes **Mathematical Models in Operations Management**

At the centre of operations research, practice and theory is a diverse set of mathematical models that are used to capture and explore a wide range of real-world settings. An operations research model is a mathematical abstraction or simplification of reality. The degree of simplification is a function of data availability, time and resources, and the situational issues and decisions that the model is designed to address. Mathematics is,

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therefore, useful as an aid in calculating and giving insight to real world situations. There are two types of models that are used:

Optimization Models: Production problems offer great opportunities for cost savings using optimization models. Such models reflect complex systems involving large numbers of decision variables and constraints and are broadly labeled mathematical programming models. Some of the most complex constrained optimization models involve tens of thousands of constraints and hundreds of thousands of decision variables. Operation researchers not only model these complex systems but also have developed algorithms that can efficiently search for optimal or near optimal solutions. Another class of deterministic models involves networks: routing through the network or optimal location on a network. Decisions involving multiple objectives can be addressed with a general class of models called Multi-Criteria Decision Analysis (MCDA).

Heuristic Models: For a great many problems, no solution technique is known at all. For these problems, heuristic solution techniques are the alternative. These are mathematical models to predict behaviour of systems that attempt to provide service for randomly arising demands. Heuristic problem solving involves finding a set of rules or a procedure, that provides satisfactory solutions to a specific problem. These models are sometimes called "good enough, fast enough'' solution techniques. There are many valuable applications of heuristic models, including traffic flow (vehicles, aircraft, people, communications), scheduling (patients in hospitals, jobs on machines, programs on a computer), and facility design (banks, post offices, amusement parks, fast-food restaurants), etc.

Mathematical models are created in a world of make-believe, and not in the real world. However, with a mathematical model in hand, the operations researcher can work with managers and decision makers to evaluate decision alternatives or system redesign. The purpose of computing is insight, but it should not replace thought.

1.1.3 The 1970s to 1980s – The Japanese Challenge

Operations research faced a new challenge in this period. Japan, without the extensive knowledge of operations research and the new models and methodologies, was able to deliver vehicles to the European market at lower costs than the Europeans themselves. This made no sense at all to the west and the industry attention moved to Japan. Since the Japanese systems produced results, this created an interest in the use of these systems.

One of the major focus areas was the Toyota production system. The Toyota production system was developed by Taiichi Ohno and is now being implemented in many western companies, usually under the names of Lean production or World Class Manufacturing program. Ohno identified seven categories of Muda (Waste), which form the basis for process improvements:

1. Defects, including rework
2. Overproduction of goods not needed/wanted by customers
3. Inventories of goods awaiting further processing
4. Unnecessary processing
5. Unnecessary movement of people
6. Unnecessary transportation of goods
7. Waiting by employees for upstream activity.

This resulted in important changes in the field of Operations Management. Holistic systems of physical and human processes that extended its reach into the whole firm in a cross-disciplinary

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manner were introduced. Some of these that had a significant impact on business practice and performance were Material Requirements Planning (MRP) systems, then later concepts such as Just-In-Time (JIT), and Total Quality Management (TQM), etc. By the end of the 1980s, researchers and practitioners were using a broader set of paradigms in their quest to improve operations. Researchers were beginning to examine higher-level issues in manufacturing strategy using an empirical approach.

Notes **Toyota Production System-Autonomation**

Although JIT systems control production quantities, defects would stop the flow of parts to subsequent operations. Such a situation is avoided by a concept called an Autonomation System. This is a Toyota coined word that means 'autonomous defects control'. It is a worker controlled quality program.

There are two versions of this. In mechanical equipment, this system is called Baka-yoke by Toyota. Machines in their factories are equipped with automatic stopping devices that detect defective parts. As soon as a defective part is detected, the machine comes to a stop so as to prevent flow of defective parts to the next operation. In manual systems, such as assembly operations, the system is called Andon. It is implemented through the worker, who is required to press a stop button that interrupts the line, when defective parts are detected. This prevents defective items from being produced in any quantity. The line is restarted when the problem has been solved.

In addition, the Yo-î-don system is used to extend the concept of teamwork on the shop floor and ensure that work at the various work stations is balanced. The system involves teamwork between adjacent operations. As workers at each station complete their work, they press a button. At the end of the cycle time, a red light lights up at the work stations where the work is not completed. The entire line stops and normally others nearby pitch in to help workers having difficulty. The line starts again when all the red lights are off again.

1.1.4 The 1990s and After

The changes and challenges of the 1970s and 1980s generated a sense of identity crisis in Operations Management. The disillusionment with Operations Management, however, was short lived. There was a refocusing of research questions. This was a crucial driver of growth of the field in the 1990s. Particularly, the research focus became more managerial (e.g., focusing on system design, information, and incentives) and less on tactical execution.

Another more important reason for the re-emerging importance of Operations Management was developments in the field of computers and communications technology. By the end of the 1980s, as the computational capacity increased dramatically, computers found use in design and production; and newer models were developed for solving operations problems. These models were application based and did not require extensive knowledge of mathematics.

Table 1.1: Historical Milestones in Operations Management

Date	Initiator	Event
1875	James Watt	The Steam Engine was commercially manufactured
1899	Eli Whitney	Introduced mass production and the concept of standard interchangeable parts
1900	Frederick W. Taylor	Scientific Management

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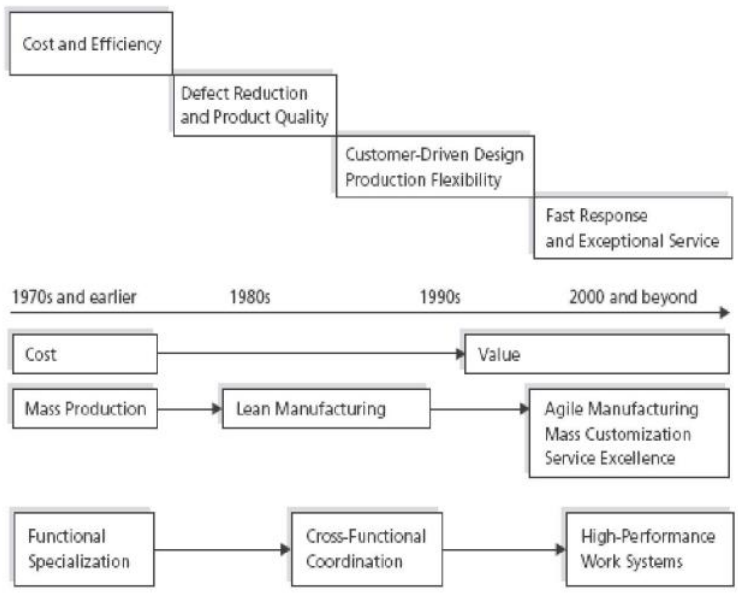
1900	Frank & Lillian Gilbreth	Time & Motion Studies
1901	Henry H. Gantt	Scheduling
1905	Henry Ford	Assembly Line
1905	Alfred P. Sloan	Organizational Management
1927	Elton Mayo	Human Resources Movement
1931	Walter A. Shewart;	Quality Control Charts
1935	H.F. Dodge & H.G. Romig	Statistical Sampling applied to quality control
1940	P.M.S. Blacket et al	Operations Research Applications
1947	George B. Dantzig et al	Linear Programming
1950	A. Charnes, W.W. Cooper & H. Raiffa	Non-linear and Stochastic Processes Programming
1970	J. Orlicky & O. Wright	Computer applications to Manufacturing – Material Requirement Planning (MRP)
1980	W.E. Deming, Philip Crosby & J. Juran General Motors & IBM	Quality and productivity applications from Japan; Computer aided Design and Manufacturing (CAD /CAM); Robotics,
1990	Netscape, US Department of Defense Michael Hammer, James Champy	Internet, Electronic Enterprise Business Process Reengineering
2000	Amazon, eBay, Yahoo, America Online Dr. Daniel Whitney and Professor Charles Fine, MIT	E-commerce, Agile Manufacturing, High performance Work systems

The combination of computer and communication advances affected the way business was conducted and it particularly impacted many service industries. The development of the better and faster microprocessors, communication technology, miniaturization, and digitization created a new lease of life and added vigour to the development of new techniques in Operations Management.

Figure 1.1: Chronology of Operations Management Themes



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Some important developments during this period were to move towards an interdisciplinary research. There was also an explicit recognition of businesses as decentralized entities of control that provided local incentives to its employees. This relationship altered the criteria for analysis. There was re-emergence of economic equilibrium and the sole-owner optimality became the focal criteria in the new approach.

Operations Management underwent three key shifts in emphasis:

- From cost and efficiency to value creation.
- From mass production to agility and customization.
- From functional specialization to a systems approach to achieving high performance.

Figure 1.1 shows the way Operations Management themes have been changing over the last four decades.

Self Assessment

Fill in the blanks:

1. Before World War II the focus of 'scientific management' was based on the …… in the manufacturing sector.
2. The concept of Scientific Management led to the development of …… study.
3. The Toyota production system is now being implemented in many western companies, usually under the names of …… or World Class Manufacturing program.

1.2 Defining Operations Management

Productive systems are those that convert or transform resource inputs into useful goods and services as outputs. Such productive systems are generally referred to as Operations systems. Operations Management, often described as Production and Operations Management (POM), relates to the management of such systems. Of the many developments taking place in the discipline in the recent past, the most radical is perhaps the concept of what the discipline represents. Up to the 1970s, Operations Management was considered as a 'centre' system with its basic focus on 'cost reduction'. Since the 1990s, it has been increasingly recognized as a 'basis' for 'value creation' within the organization.

Both these views on Operations Management co-exist today. In smaller organizations where the competition is price sensitive, markets are small and the customer needs are well defined, the focus is on the cost reduction aspect of Operations Management. However, as organizations grow, the parameters of competition increase, market logistics become more complex and customers become more demanding, the focus of Operations Management as a 'value creation' function, provides greater rewards.

1.2.1 Modern vs. Traditional Approach

There are, therefore, two ways – traditional and modern – in which Operations Management is viewed:

1. The traditional view perceives Operations Management as a system that is involved with the manufacture and production of goods and services.
2. The more modern view perceives Operations Management as a system designed to deliver value.

Let us discuss these two perspectives in greater detail.

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1.2.2 Transformation Approach

The traditional definition considers Operations Management to be a transformation system. According to this view:

Operations Management is the business function that manages that part of a business that transforms raw materials and human inputs into goods and services of higher value.

According to this definition, Operations Management transforms inputs into outputs of goods or services.

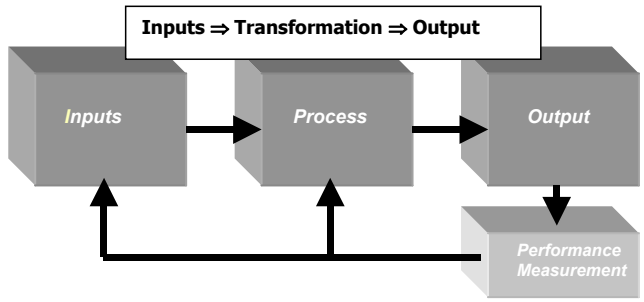
Example: A manufacturing plant takes raw materials in the form of parts, components, and subassemblies and transforms them into a manufactured product such as an automobile, by the use of resources such as labour, capital, and energy.

It is the task of Operations Management to set-up and run the system that can produce or provide the required outputs. The specifications of the outputs are the starting point. For getting the desired output, the specifications and quality of the inputs is first determined. The responsibility of Operations Management is to transform these inputs into outputs in such a way that the outputs have greater value than the costs of inputs plus the costs related to investments in the process.

This is because, in a system based on the input-output concept, controls can be basically exercised on variable costs. The variable costs are made up of the input costs and the process costs. Once a process has been selected, it is difficult to alter the processes; therefore, process costs are relatively stable. The input costs reflect that part of variable costs that can basically be controlled. Control of input costs, therefore, becomes the basis for the measurement of performance of the system.

Did u know? The primary system of analysis and control of the effectiveness of the Operations Management system is the breakeven analysis.

Figure 1.2: Operations Management as a Transformation Process



Operations Management has a number of functions to carry out the transformation process effectively. The functions incorporate different roles that are interdependent but which can be grouped under five main headings:

1. ***Product:*** The role of Operations Management is to ensure that the product is manufactured as per specifications and the plan.
2. ***Plant:*** In order to make the product, plant and equipment is required; Operations Management has to consider that the plant meets specifications and is in keeping with the requirements.

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3. ***Process:*** There are many ways of producing the product, and Operations Management has the responsibility of choosing the best way.

4. ***Program:*** The production programme ensures that the schedules of production are met.

5. ***People:*** Production depends on people and their skills and motivation. Operations Management has to ensure that skilled and motivated workers are available.

Operations Management, seen in this way, is the science of optimizing transformation processes, during which 'sets of inputs' are converted efficiently and economically into outputs, with the objective of improving profitability of the organization. We will discuss the components of Operations Management in the value driven approach. As the value driven approach is broader based, this traditional view becomes a subset of the larger landscape.

1.2.3 Value Driven Approach

The second approach is a value driven approach to operations management. The value driven approach starts by recognizing that a business is a 'set of processes', each of which has inputs, outputs, and structure. Each process has a job to do and each process should be measured on how effective it is in achieving the desired outcomes.

The Core Process Model as shown in Table below is a simple model, based on the four core business processes describing the functioning of a business organization. There can be many more core processes depending upon the business and how it is structured.

Table 1.2: Core Process Model

	SUPPORTING BUSINESS PROCESSES				
CORE PROCESSES	**Determine Customer Needs**	Monitor Competitive Environment	Market Products & Provide After-Sales Service	Measure Customer Satisfaction	Understand Customers, Market Segments & the Competitive Environment
	Develop Product Strategy	Evaluate Product Concept	Create New Products Design or Product Improvements	Build and Test Prototypes	Develop New Products or Product Improvements
	Secure Processes & Materials to Satisfy Demand	Operations Planning & Control Processes	Manage Product Transformation Processes	Manage Business Logistics	Manage the Supply Chain Process
	Manage Strategic Planning Processes	Manage Human Resources	Manage Information Systems	Manage Financial Resources	Enterprise Management & Business Support Activities

The four core business processes in this model are described below:

1. ***Determine Customer Needs:*** It is critical for the organization to know the customers needs in order to support the firm's demand, its forecasting needs and its product design and development activities. The supporting business processes are involved in marketing products and providing after-sales service. There has to be a measure of customer satisfaction. There is also a requirement to understand the specific needs of different market segments and the nature of the competitive environment. For fast-pace firms, Customer Relations Management (CRM) has become important. Many software firms in India are developing applications that are designed to keep them in a position to understand what their customers want and in some cases, how it can enhance the marketing capabilities of its sales force.

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Caution In order to determine customer needs, it is necessary to monitor the competitive environment.

2. ***Develop Product Strategy:*** This involves marketing, operations, and engineering activities in order to create products that customers desire. This requires an ability to evaluate product concepts so that there is support to design new products or introduce product improvements. The slower the pace, the more is the focus on delighting customers by finding better ways to incrementally improve products that already exist. But as the pace of business increases, the greater is the need to be aware of the competitive challenges that new technologies and competitors introduce into the marketplace.

   The organization has to develop the ability to understand the potential customer and the pleasing/displeasing consequences associated with changes. An aggressive competitive market exploits the limitations of an organization; as such, it has to possess the ability to design, build and test prototypes, and develop new products or product improvements before the competition. The risk is that if the firm does not replace, upgrade its existing products in time, some other firm will.

3. ***Secure Processes and Materials to Satisfy Demand:*** Management activities involve selection of raw materials from vendors and the ultimate delivering and servicing of the product for the customer. These activities include operations planning and control processes and managing the product transformation processes. In addition, the business logistics and the supply chain process play a critical part and have to be managed effectively. In today's world, supply chain players are widely distributed and will seldom lie within the firm's boundaries, hence making the need to manage the flow of materials effectively more challenging.

4. ***Manage Strategic Planning Processes:*** Support business processes are essential to all organizations. The strategic planning process defines the firm's as well as its own Operations Management function. It also specifies what it must do to achieve its corporate goals. The human resource management function creates an organization design that is suited to the competitive environment and provides and/or enhances the human capital needed by other functions to effectively carry out their tasks. The Management Information Systems groups provide timely information that is needed to assess the competitive environment and the performance of its business functions. The accounting and finance groups monitor the use of financial assets and take steps to ensure that the financial base of the organization is both adequate and efficiently utilized. There has to be an adequate interface between all these functions.

Operations Management activities are mostly involved in the second and third core processes. Operations Management, as a value creating activity, contributes to the customer satisfaction process by assisting to design and develop products that possess the capability to satisfy the customer's functional need with the desired level of design, quality and cost. Operations Management is defined as the following:

Operations Management constitutes all of the activities that an organization conducts in order to deliver value to its customers. It is the set of processes that transforms either materials or information into a product or service.

The operations function contributes to the 'value' delivery to customers by significant improvements in the cost, quality, timeliness, and availability of products and services. Organizations can use effective Operations Management either to show improvements in performance and quality, coupled with lower prices in real value, or to help raise their bottom-line.

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Consider the Consumer Durables Sector in India: during the last twelve months, the market leaders have given a lead by lowering prices by 25-40 per cent on almost their entire product range. The decline in prices is attributed to substantial value engineering and technology improvement. This in turn has resulted in a 16-18 per cent increase in consumer demand for the industry. Such dramatic changes are also seen in other technology products.

On the other hand, during the same period in the FMCG segment, most leading companies have reported appreciable growth in profits despite the reductions in sale and sagging top-lines. They have managed to effectively protect prices by squeezing costs through better sourcing, better supply chain and by reducing overhead costs. The average profit growth has been in the region of 10 per cent while average sales have reduced by 5 per cent.

The Value Chain Model

In the overall execution of the core processes, Operations Management plays an exceedingly important role. Operations Management processes are designed to deliver value and contribute to the customer satisfaction process in two significant ways:

- Operations Management assists in the organization's product innovation process to design and develop products that can satisfy the customer's functional need with the desired level of design quality and cost.
- Product Design determines product specifications to meet customer needs; Process Development subscribes the production methods necessary to make the products.

These two functions have to work together, for innovation and systematization go hand in hand. It is only possible with tight integration between these two functions that more new products can be launched faster. Shrinking product lifecycles makes this an important requirement, especially for fast clock-speed industries.

Operations Management designs and manages the value chain for manufacturing goods and delivering services, i.e., the process and supply chain needed to create, deliver, and service the products sold. It is in addition, involved in designing and managing processes that support the value chain—such as purchasing and materials management, storage and transportation, customer support, and work systems.

Did u know? Initiatives such as simultaneous engineering and early supplier involvement in the product design process elevate the role of operations in the product and service concept design process.

Its performance metrics in delivering value in controlling and improving the value chain and support processes to achieve and sustain high levels of business and organizational performance can be judged on its capability to:

- Deliver a product that measures up to design specifications,
- Be flexible enough to offer products to customers depending on how, when, and where they want it, and
- Do the above at an acceptable cost.

Operations Management is no longer merely something that has to "get done" in order to proceed with business as usual. It successfully helps organizations to squeeze out the waste, and to focus on how to differentiate from competitors in meaningful ways. Where Operations

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Management was once viewed primarily as a manufacturing function, service firms are now recognizing its tremendous competitive potential. Instead of a focus on cost, the focus now encompasses reliability as well as delivery times. Operations Management is now a major contributor to the design and management of the supply chain needed to create, deliver, and service the products sold.

Self Assessment

Fill in the blanks:

4. The ……view perceives Operations Management as a system that is involved with the manufacture and production of goods and services.
5. The …… view perceives Operations Management as a system designed to deliver value.
6. Operations Management designs and manages the …… for manufacturing goods and delivering services.

1.3 Operations Management Basics

The value driven approach focuses on the value provided to the customer. Customers are those who purchase final goods and services. Those who ultimately use the products are called consumers.

The consumer and the customer may not be the same person.

Example: It is known that wives generally buy their husband's wardrobe. Here, the consumer is the man while the customer is the woman.

Similarly, the recipients of goods and services from external suppliers are called external customers, while the recipients of goods and services from internal suppliers are called internal customers.

Example: In Escorts Ltd. the engine plant of the Tractor Division in 'Plant I' purchases engine castings from Menon & Menon in Kohlapur, the engine plant is an external customer of the casting company. In turn, the engine plant supplies the machined engine block to the Tractor Assembly in 'Plant III'. 'Plant III' is an internal customer to 'Plant I'.

This distinction between consumers and customers (internal and external) is important for operations managers. The concept of internal customer has profoundly changed Operations Management thinking. It helps employees understand how they fit into the system and how their work contributes to the final product, and it enables managers to view the organization as a system. The needs of each group are quite different and lead to different operations capabilities that must be met.

Example: A consumer product company like Hindustan Lever must pay attention to consumers' needs for product quality and performance, as well as to external customers' (an independent retail outlet like Morning Stores in Delhi) needs to supply the right products at the right time.

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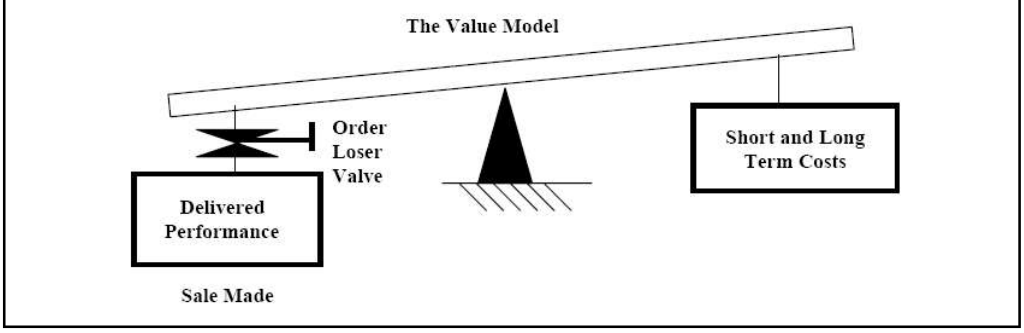
Figure 1.3: The Value Seesaw



The 'value' concept is represented by the value seesaw, shown in Figure 1.3.

The right-hand box represents the product-life cost associated with acquiring, operating, and disposing of the product. For a simple product, such as a bar of Cadbury's chocolate, there is the price of the chocolate and perhaps some tooth decay, too. Note that the customer – perhaps your mother – worries about tooth decay, but you as a consumer are less concerned with this long-term consequence. For other products, such as a nuclear power plant, calculating the lifecycle costs of the product is more difficult since its economic life and end-of-life disposal costs are hard to estimate.

The left-hand box represents the sum of the benefits that will occur if the product is purchased and consumed. No matter how cheap a chocolate is, consumers won't want it if it doesn't satisfy a need. What we need is some means to measure these benefits.

The value of a product is the ratio of performance divided by cost as is shown in the equation below:

$$Value = Performance / Cost$$

Where:

$$Performance = f\ (functionality, quality, speed, timeliness, flexibility).$$

If a company's product is compared with that of a competitor's product, the product with the highest ratio will be the most valued by the customer. This is the value equation.

Performance is defined by the cumulative benefits that will result if the product is purchased and used as intended.

When a product or service is purchased; the buyer has an intended use for it. Functionality is a measure of the extent the product, when properly used, is able to accomplish the intended feat.

Quality is broadly defined as the extent to which a product or service is delivered in consistence with what the customer has been led to expect.

An organization's speed is often measured in two dimensions:

- How long a customer must wait for the product once it is requested, and
- How long it takes to design, develop, and introduce new products.

Did u know? **What is Timeliness?**

Timeliness is the ability of a firm to get the right product to targeted customers at the most desirable time.

Notes

Flexibility is the input to the value equation relating to the ability of the Operations Management system to give the customer the desired product.

Operations managers evaluate cost, measured in money terms, for its contributions in two important roles:

- Enhancing value, and
- Serving as a performance metric for evaluating business processes.

The element in the value equation that is of primary importance is often called the order winner. Order winners are attributes that reflect a customer's preference and dominate the other elements of value. Excellent food offered by a restaurant may be an order winner. Over time, order winners often evolve into order qualifiers, as the value provided by competition improves.

Example: Sony's Trinitron picture tube that was an order winner became an order qualifier as the quality of competition improved. Having a high-quality picture tube was no longer enough for Sony to win the customer.

Sometimes, a value equation component has a trait that can make the consumer decide in not purchasing the product. Such traits are called order losers. Human rights activists dissuade people from buying products made through child labour. In this case, products identified as being produced by children become order losers.

Self Assessment

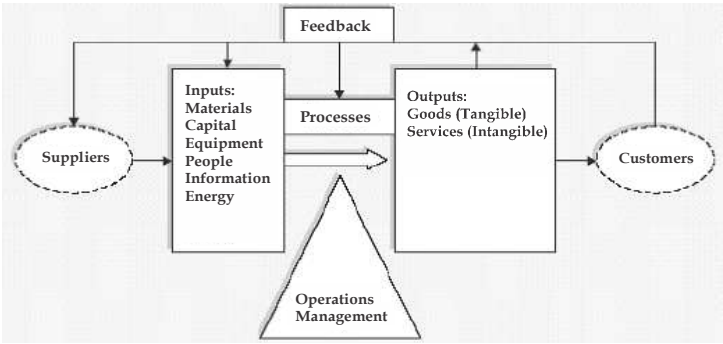
Fill in the blanks:

7. The concept of …… customer has profoundly changed Operations Management thinking.
8. …… is a measure of the extent the product, when properly used, is able to accomplish the intended feat.
9. The element in the value equation that is of primary importance is often called the …… .

1.4 The Operations Manager's Role

A modern operations manager performs many roles. Figure below reflects the relationships between the various process components of the business environment. As will be seen from the figure, unlike the transformation approach, the organizational relationship starts with the external environment that includes suppliers and customers. There is a continuous feedback into the system which makes the environment dynamic.

Figure 1.4: Value Driven Concept of Operations Management



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In this dynamic environment, the operations manager must understand his roles. These keep modifying and the focus keeps changing in the context of the forces of change that operate and impact the functioning of the organization. The roles of the operations manager have to be suitably moderated depending on the changed circumstances. The primary role of the operations manager is to accomplish the department's mission as best as possible.

The department's mission can be segregated into three different decision areas. These are as follows:

- Structural decisions,
- Infrastructural decisions, and
- Organizational decisions.

Structural decisions refer to the 'hardware' of organizations; they are long-term decisions that require substantial capital investment and are difficult to reverse once they are in place.

Example: The structural decisions are the number and size of facilities and the type of processing equipment.

Infrastructural decisions are the 'software' of operations. These are typically tactical in nature and facilitate the management of day-to-day issues.

Example: Machine loading and the changing of 'dies' in a forging unit.

Table given below describes the decision areas in detail.

Category	Decision Area	Typical Questions	Contemporary Challenges
Structure	Products *(What?)*	• Do we produce standard or custom products and services? • Do we make to order or make to stock?	• How do we design products and services that are easy to make? • How can we coordinate design teams that are scattered across the world?
	Processes *(How?)*	• What kind of equipment should we use? • How much of the process should be automated? • How should processes be configured?	• How do we exploit new IT developments such as the Internet for rapid and flexible response to customer needs?
	Capacity *(How much?)*	• How much is needed? • What type? • When should capacity be increased or decreased?	• How do we use flexible capacity options (such as temporary workers) and economies of scope for competitive advantage?
	Facilities *(Where?)*	• Where are they located? • What products should be produced in each?	• How do we manage and exploit global opportunities for locating facilities?
Infra-structure	Quality Management *(How to improve?)*	• How do we prevent defects and errors? • How do we improve products and processes?	• How can we better learn from customers? • How can we improve quality to world-class standards?
	Schedule Management *(When?)*	• Should scheduling be centralized or decentralized? • How do we prioritize work and/or customer orders?	• How do we use available cost and financial information in scheduling? • How do we integrate enterprise resource planning systems into operations?

Contd...

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	Inventory and Supply Chain Management *(How to acquire and deliver?)*	• What products should we outsource? • How many suppliers should we use?	• How do we manage the supply chain for increased value to the customer? • What effect does the Internet have?
People and organi-zation	Workforce and Productivity *(Who?)*	• What skill level and training should employees have? • What types of compensation and reward systems are best?	• How can we develop truly "high-performance" work systems? • How can we better align work systems with long-range plans and objectives?
	Organization *(What structure?)*	• Is a hierarchical or team-based work structure better? • Should we train in-house or outsource?	• What structures are best suited for operations in different countries? • Should we "flatten" the organization? • Lean Manufacturing
	Strategy *(How to manage growth?)*	• How to respond to customer's special needs? • What information do we need to effectively manage growth?	• How can we develop a learning organization in a globalized environment? • How can we best look at the organization across functional boundaries?

The departmental mission will to a large extent depend on the nature of the product whether the organization is dealing with goods, services or contracts. Whatever the product, the department's mission is judged on three major components:

- Cost minimization,
- Delivery reliability, and
- Product quality.

Equally if not more important, is the ability to manage humans in a way that is mutually satisfying to the subordinates, peers, and superiors and this involves getting the necessary things done.

Effective operations managers must show commitment—both to their employees and to the organization's objectives.

Workers expect good managers to be fair and impartial. In an era of downsizing and disintermediation, workers would like to feel that their manager is an effective advocate when it comes to advancing or protecting their jobs.

This advocacy role is often in conflict with another real corporate need—the need to have team players that understand and are committed to the corporate mission. Resolving this conflict to everyone's satisfaction is often an art. Operations Management is also the art of getting work done through people.

The operations manager is also the supply chain manager/coordinator. In a manufacturing organization,

Example: The manager must view the entire flow of goods and information within the supply chain, whether this falls within the corporation's legal boundaries or within that of suppliers and customers outside the organization.

The operations manager also has duties that involve cross-functional participation with the business processes in the other three core processes. The most important non-supply chain business process is the product innovation process. But activities involving human resource management, accounting, marketing, and R&D processes also are critical contributors to the operations manager's effectiveness.

Notes

In fast paced business settings, since operations managers are amongst those closest to the customer, they can provide quick feedback to the strategic planning process regarding the changes in the market. Good operations managers are expected to manage existing business processes while helping get the firm ready for the future.

Task Take a hospital, say Apollo Hospital, and explain the conversions taking place. What are the hospital's overall objectives of the operations systems and how does the hospital achieve it.

Self Assessment

Fill in the blanks:

10. The primary role of the operations manager is to accomplish the …….mission as best as possible.
11. ……..decisions refer to the 'hardware' of organizations.
12. Infrastructural decisions are the …….of operations.

Caselet

New United Motor Manufacturing (NUMMI)

Established in 1984 as a joint venture between General Motors Corp. and Toyota, New United Motor Manufacturing (NUMMI) took over the former General Motors plant. The plant, on 211 acres east of Interstate 880 and south of Fremont Boulevard, occupies about 5.3 million square feet. This was a 50-50 joint venture that produced Toyota Corollas and Chevrolet Novas.

Toyota's secrets aren't secret. Its production system, which stresses eliminating all wasted material and labour, has been written about in excruciating detail. NUMMI is proof of this. The plant, which had operated from 1963 to 1981, had been closed down as it was plagued by labour disputes. Toyota turned the plant around extra quick. They hired the best of the former workers and created teams of multi-skilled workers. Absenteeism dropped to less than 2 per cent compared to 20 per cent under the old management. Productivity at the plant rose to twice the average level at other GM plants. The Toyota managers achieved this improvement by focusing on five areas:

1. New products were designed for easy assembly and easy modification.
2. Production layout was organized by product needs.
3. Production flow was managed with little or no inventory.
4. Workers shared responsibility for quality.
5. Employees were encouraged to participate in nearly all decisions.

The system improvements did not come from technology investment; it was transformed by how the managers were able to integrate the different elements into a coherent operations strategy. Even without much automation, each worker was producing 63 cars a year by 1989, more than any other US plant and 40 per cent above the average at that time.

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Twenty years later in 2004, the company sells 2.1 million vehicles in North America. Today, NUMMI continues to flourish as a company of 5,000 team members. With Toyota's engineering content, Toyota's managers transformed an antiquated NUMMI assembly plant into GM's most efficient factory using what is described as the "Toyota Way" – a corporate philosophy that empowers employees.

1.5 Interface with other Functions

Well-designed manufacturing and service operations 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 operations 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 Operations 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 operations 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. ***Operations 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 operations strategy.

   In addition, marketing is the key information gatekeeper between operations 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 operations and marketing decisions go back over many decades.

   Conflicts between operations 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 operations and marketing propels many organizations to higher levels of effectiveness.

2. ***Operations 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 operations need to work together to understand the nature of technology used in operations 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. Operations 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.

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3. ***Operations 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 Operations Management functions. Initiatives such as simultaneous engineering and early supplier involvement in the product design process not only add to the role of operations 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 operations. Therefore, co-operation between these three functions, i.e., process engineering, design and operations, leads to improved organizational performance.

4. ***Operations 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 operations function interact significantly with both structural and infrastructural decisions. Such issues are not unique to the operations function, however; they impact other functions and are dealt with more effectively through the human resource management function.

   As organizations increasingly opt for 'flextime', the operations function has to develop unique process configurations to accommodate employees with minimum disruption in the flow of work. Operations Management and Human Resource departments have to co-operate for recruiting and training employees, enhancing employee well-being and development, and fostering motivation that are vital to the success of management policies in practice.

5. ***Operations Management-Information Systems:*** Information systems provide, analyze, and co-ordinate the information needs of operations. The distributed processing environment and the growth and evolution of Enterprise Resource Planning (ERP) systems for the organization have a direct impact on operations. 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.

Caution 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.

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 operations 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. Operations Management measures the effectiveness of people,

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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.

Self Assessment

Fill in the blanks:

13. The firm's strategic positioning and its …… segmentation decisions to a large extent determine the manufacturing and operations strategy.
14. Decisions about people and the organization of the operations function interact significantly with both structural and …… decisions.
15. The effectiveness of operational planning and budgeting is driven by the level of …… between these two areas.

1.6 Summary

- The class of problems represented by Operations Management came into high relief in the era after the Industrial Revolution.
- An important reason for the re-emerging importance of Operations Management was developments in the field of computers and communications technology.
- The traditional view perceives Operations Management as a system that is involved with the manufacture and production of goods and services.
- The more modern view perceives Operations Management as a system designed to deliver value.
- This distinction between consumers and customers (internal and external) is important for operations managers.
- The roles of the operations manager have to be suitably moderated depending on the changed circumstances.
- The primary role of the operations manager is to accomplish the department's mission as best as possible.
- Finance provides data on product and service costs that help managers evaluate operational performance.
- The distributed processing environment and the growth and evolution of Enterprise Resource Planning (ERP) systems for the organization have a direct impact on operations.

1.7 Keywords

Contracts: These constitute business exchanges in which neither services nor goods are transferred; instead, there is an implicit understanding between the customer and the provider that goods and services will be provided on an "as needed" basis.

Goods: These 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.

Operations Research (OR): Operations research is the application of scientific methods to improve the effectiveness of operations, decisions and management.

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Services: Services are intangible products that are consumed as they are created. Direct customer contact is a key characteristic of services.

Value Model: People part with their money to buy a product when it delivers more "value" than the value they attribute to the money exchange.

1.8 Review Questions

1. Why do you need to accept that Operations Management should be viewed as a system?
2. What are the subsystems within the operations function and what is their salience?
3. Define operations processes and explain its key components.
4. What challenges do operations managers face in managing processes?
5. What is the systems view of Operations Management?
6. Processes can result in tangible or intangible products. There are different elements involved in these two types of processes. Distinguish between the different aspects of these processes.
7. Well-designed manufacturing and service operations exploit a company's distinctive competencies – the strengths unique to that company – to meet these needs. Explain.
8. Explain the important issues with transformation.
9. Many other firms have excelled at operations to improve their competitive position. The student is expected to show how these competencies and strengths have been brought about in Operations Management.
10. Operations manager of a firm has to coordinate with other departments in order to organize the production activities in an effective manner of the firm. Explain.

Answers: Self Assessment

1.	micro-environment	2.	time and motion
3.	Lean production	4.	traditional
5.	modern	6.	value chain
7.	internal	8.	Functionality
9.	order winner	10.	department's
11.	Structural	12.	'software'
13.	market	14.	infrastructural
15.	co-operation		

1.9 Further Readings

Books

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

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

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Online links

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Unit 2: Strategy and Operations Strategy

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Objectives

After studying this unit, you will be able to:

- Recognize the competitive capabilities relationship with operations strategy;
- Describe the objectives of competitive operations strategy;
- Discuss the model developed by Richardson, Taylor and Gordon;
- Explain the implementation of operations strategy.

Introduction

Peter Drucker says, "The primary tasks of Strategic Management are to understand the environment, define organizational goals, identify options, make and implement decisions, and evaluate actual performance". The aim of strategic analysis is to form a view on the key

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factors that will have an affect on the future well being of the organization. Strategic analysis enables us to identify and understand the potential opportunities and constraints that exist for our organization. It will enable us to make informed strategic choices about the future of our organization. What opportunities are offered to it and does it have the capability to take up the opportunity.

2.1 Relationship between the Different Value Elements

Unless the firm's performance metric system is able to measure customer satisfaction, it risks being penny wise and pound foolish when it comes to measuring customer service costs. Marketing uses a concept called the 'Lifetime Value of a Customer' in which it estimates the stream of income a firm can expect to receive from a satisfied good customer.

Timeliness in the value model varies because it is both individual specific and situation specific. Its measure is delivery reliability. When customers are told a product will be delivered on a specific date, they value the product higher when that promise is kept. Anything less diminishes the value of the firm's product. Delivery reliability also enables the supply chain to operate effectively with lower levels of inventory.

Lastly, improving flexibility can affect the other elements of value. Flexibility affects lead-time and quality through the synergistic relationships among the three elements of the numerator of the value equation. Reductions in lead times affect flexibility; improvements in flexibility benefit quality; improvements in quality reduce lead times and enhance flexibility.

Did u know? **What is Flexibility?**

Flexibility is the input to the value equation relating to the ability of the OM system to give the customer the product desired.

All these factors together with productivity and cost, improve the company's ability to improve on its competitiveness and profitability. This allows the organization to do many things, such as:

1. Expand its operations, and thus create employment and opportunities for employees to advance;
2. Invest in advanced technology and systems that will further enhance its productivity;
3. Pay employees better wages and provide them a better working environment, thus raising their work morale and standard of living; and
4. Contribute more to the society by paying a higher quantum of corporate tax, and supporting more social causes.

Self Assessment

Fill in the blanks:

1. Flexibility affects lead-time and quality through the synergistic relationships among the three elements of the numerator of the …… .
2. Delivery reliability enables the supply chain to operate effectively with …… levels of inventory.
3. Marketing uses a concept called the 'Lifetime Value of a Customer' in which it estimates the …… a firm can expect to receive from a satisfied good customer.

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4. Timeliness in the …… model varies because it is both individual specific and situation specific.

2.2 Competitive Strategy

Corporate Strategy and Objectives have a major impact in determining the different operational parameters at the corporate level. We have discussed some of these in the previous section, however, 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.

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:

- Cost Leadership,
- Differentiation, and
- Focus Strategies.

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.

The Generic Competitive Strategies are shown in Figure below. These strategies need to be examined in conjunction with the 'competitive capabilities' of the organization and the external environment. Effectively implementing any of the generic competitive strategies usually requires total commitment and determined organizational support from OM. There needs to be compatibility between corporate level strategy and the strategy at the operational level.

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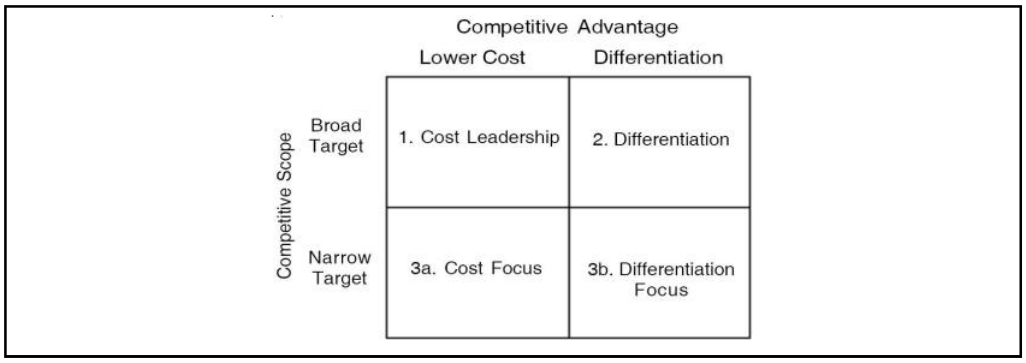

2.2.1 Cost Leadership Strategy

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.

The skills and resources required to be successful in this strategy are sustained capital investment and access to capital; superior process engineering skills; good supervision and motivation of its labour force; product designed for ease in manufacturing; and low-cost distribution system.

Notes The organization attempts to exploit economies of scale by aggressive construction of efficient economies of scale through:

1. Volume of production and specialized machines
2. Volume of production and cost of plant and equipment
3. Volume of production and employees specialization
4. Volume of production and overhead costs.

This strategy requires tight cost control. This is often done by using a full costing method or activity based costing with frequent and detailed control reports. The structure of the organization should be clear-cut and responsibilities clearly laid out. Organizations often provide incentives based on meeting strict quantitative targets, etc.

In order to remain a cost leader, the firm attempts to avoid those factors that can cause the economies of scale to be affected. It has to work within the physical limits to efficient size; worker motivation; and focus on markets and suppliers, sometimes in restricted geographical areas. Firms that are known to have successfully used this strategy in a number of their businesses include Black and Decker, Texas Instruments, and Du Pont.

The 'low-cost producer' strategy works best when buyers are large and have significant bargaining power; price competition among rival sellers is a dominant competitive force; the industry's product is a standard item readily available from a variety of sellers; there are not many ways to achieve product differentiation that have value to the buyer; and when buyers incur low switching costs in changing from one seller to another and are prone to shop for the best price.

A low-cost leader is in the strongest position to set the floor on market price and this strategy provides attractive defences against competitive forces. Its cost position gives it a defence from competitors because its lower costs mean that it can still earn returns after its competitors have competed away their profits through rivalry. It is protected from powerful buyers because buyers can exert power only to lower prices, and this will be possible only with the next most

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efficient competitor. Lower cost provides protection against suppliers because there is more flexibility in the organization to cope with input cost increases. Any new entrant will find it difficult to overcome entry barriers because of scales of economy and as the activities taken to achieve low costs are both rare and costly to imitate.

Finally, it places the organization in a favourable position when pitted against substitutes compared to competitors in the industry.

Cost leadership is valuable if:

1. Buyers do not value differentiation very much
2. Buyers are price-sensitive
3. Competitors will not immediately match lower prices
4. There are no changes in
   (i) consumer tastes
   (ii) technology
   (iii) exogenous prices/costs

There are a number of risks in using this strategy. These risks relate to the fast changing business environment. The most important risk to cost leadership is technological change that nullifies past investment or learning of the organization. Sometimes the inability of the management to see or anticipate the changes required in the product or market change, is a risk. The organization's advantage can also be neutralized if there is low cost learning by industry newcomers or inflation in costs of supplies or processes that provide the organization a competitive advantage.

2.2.2 Differentiation Strategy

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.

The challenge is finding ways to differentiate that create value for buyers and that are not easily copied or matched by rivals. Anything a company can do to create value for buyers represents a potential basis for differentiation. Ways to differentiate products/services include:

1. Product features
2. Linkage between functions
3. Timing
4. Location/convenience
5. Product mix
6. Links with other firms
7. Customization
8. Product complexity/sophistication
9. Marketing (image, etc.)
10. Service and support

Notes

Successful differentiation creates lines of defense against the five competitive forces. It provides insulation against competitive rivalry because of brand loyalty of customers and hence lower sensitivity to price.

The customer loyalty also provides a disincentive for new entrants who will have to overcome the uniqueness of the product or service. Competitors are not likely to follow a similar approach if buyers value the differentiated products and services. If they do, this will lead to a lose-lose situation for them.

The higher returns of the strategy, provides a higher margin to deal with supplier power. Buyer power is mitigated as there are no comparable alternatives. Finally, a company that has differentiated itself to achieve customer loyalty should be better placed to compete with substitutes than its competitors.

Example: Mercedes in automobiles, Bose in audio systems and Caterpillar in construction equipment.

Competitive advantage through differentiation is sustainable if the activities taken to achieve differentiation are rare and costly to imitate. The most appealing types of differentiation strategies are those least subject to quick or inexpensive imitation. Differentiation is most likely to produce an attractive, long-lasting competitive edge when it is based on technical superiority, quality, giving customers more support services, and on the core competencies of the organization.

Differentiation requires the organization to have some of these skills and resources:

1. Strong marketing abilities
2. Product engineering
3. Creative flair
4. Corporate reputation for quality or technological leadership
5. Strong cooperation from channels
6. Strong coordination among functions
7. Amenities to attract highly skilled labour, scientists, or creative people.

Differentiation strategy works best when there are many ways to differentiate the product/service and these differences are perceived by buyers to have value or when buyer needs and uses the item are diverse. The strategy is more effective when not many rivals are following a similar type of differentiation approach.

Caution There are risks in differentiation strategy when the cost of differentiation becomes too great or when buyers become more sophisticated and need for differentiation falls.

2.2.3 Focus and Niche 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.

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There are two aspects to this strategy: the cost focus and the differentiation focus. In cost focus, a firm seeks a cost advantage in its target market. The objective is to achieve lower costs than competitors in serving the market—this is a 'low cost producer' strategy focused on the target market only. This requires the organization to identify buyer segments with needs/preferences that are less costly to satisfy as compared to the rest of the market. Differentiation focus offers niche buyers something different from other competitors. The firm seeks product differentiation in its target market.

Both variants of the focus strategy rest on differences between a focuser's target market and other markets in the industry. The target markets must either have buyers with unusual needs or else the production and delivery system that best serves the target market must differ from that of other industry segments.

Cost focus exploits differences in cost behaviour in some markets, while differentiation focus exploits the special needs of buyers in certain markets. A focuser may do both to earn a sustainable competitive advantage though this is difficult.

Examples: Rolls-Royce in luxury automobiles and Apple Computers in desktop publishing.

Focus strategy is successful if the organization can choose a market niche where buyers have distinctive preferences, special requirements, or unique needs and then developing a unique ability to serve the needs of the target buyer segment. Even though the focus strategy does not achieve low cost or differentiation from the perspective of the market as a whole, it does achieve this in its narrow target. However, the market segment has to be big enough to be profitable and have adequate growth potential.

The organization has to identify a buyer group or segment of a product line that demands unique product attributes. Alternatively, it has to identify a geographical region where it can make such offerings.

Focusing organizations develop the skills and resources to serve the market effectively. They defend themselves against challengers via the customer goodwill they have built up and their superior ability to serve buyers in the market. The competitive power of a focus strategy is greatest when the industry has fast-growing segments that are big enough to be profitable but small enough to be of secondary interest to large competitors and no other rivals are concentrating on the segment. Their position is strengthened as the buyers in the segment require specialized expertise or customized product attributes.

A focuser's specialized ability to serve the target market niche builds a defense against competitive forces. Its focus means that either the organization has a low cost position with its strategic target, high differentiation, or both. The logic that has been laid out earlier for cost leadership and differentiation is also applicable here.

Some of the situations and conditions where a focus strategy works best are:

1. When it is costly or difficult for multi-segment rivals to serve the specialized needs of the target market niche;
2. When no other rivals are concentrating on the same target segment;
3. When a firm's resources do not permit it to go after a wider portion of the market;
4. When the industry has many different segments, creating more focusing opportunities and allowing a focuser to pick out an attractive segment suited to its strengths and capabilities.

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Caution A focus strategist must beware of events that could impact the target market. This can happen when broad-line, multi-segment competitors may find effective ways to match the focused firm in serving the narrow target market, or the segment may become so appealing that it is soon crowded with eager, aggressive rivals, causing segment profits to be split.

Often, the niche buyer's preferences and needs drift more and more towards the product attributes desired by the market as a whole; this could be threatening. The focus strategy always implies some limitation on the overall market share achievable. The strategy involves a trade-off between profitability and sales volume.

2.2.4 Some Aspects of Generic Strategies

The three generic strategies differ on many dimensions. Implementing them successfully requires different resources and skills. These have been summarized in the Table 2.1. Organizations pursuing different strategies will find that they attract different sorts of people. This should result in different styles of leadership that can translate into different corporate cultures and atmospheres.

Table 2.1: Summary of Generic Strategies

Generic Strategy	Required Skills and Resources	Organizational Requirements
Cost Leadership	- Sustained Capital Investment capability and access to Capital. - Process Engineering Skills. - Intense supervision of labour. - Product designed for ease in manufacture.	- Tight cost control. - Frequent, detailed control reports. - Structured organization and responsibilities. - Incentives based on meeting strict quantitative targets.
Differentiation	- Strong marketing abilities. - Product engineering. - Creative flair. - Strong capability in basic research. - Reputation for quality or technological leadership. - Long tradition in the industry or unique combination of skills from other areas. - Strong cooperation from channels.	- Strong coordination among functions in R&D, product development and marketing. - Subjective measurement and incentives instead of quantitative measures. - Amenities to attract highly skilled labour, scientists or creative people.
Focus	- Combination of the above, directed at the particular strategic target.	- Combination of the above, directed at the particular strategic target.

If the organization is in a position where it is between the three strategic options, it usually takes time and sustained effort to come out of this position.

In spite of the fact that successfully executing each generic strategy involves different resources, strengths, organizational arrangements, and managerial style, some organizations try to flip

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back and forth among the generic strategies. In addition, the organization would be amenable to a blurring of the corporate culture and conflicting motivation system. Obviously, this happens when organizations do not exercise their options based on their capabilities and limitations.

An organization must take a fundamental strategic decision to select one of the three generic strategies. Failing to develop a strategy in any of the three directions will result in low profitability. It will either lose the high volume customers who demand low prices or operate with reduced profits to lure this business away from the low cost competition. It will also lose high margin businesses to competition that have achieved differentiation overall.

This seems to indicate that in many industries there is a U-shaped relationship between profitability and market share. The profitability is high with low market share using a differentiation strategy and a high market share using a cost leader strategy.

Example: In the automobile industry the profit leaders are General Motors that has a price leadership strategy and Mercedes, which has a differentiation strategy.

The three strategies are based on competing differently in the marketplace. They construct different types of defences against competitive forces. The types of risks they face are also different. However, there are two types of risks that are common to all of them:

1. Failing to attain or sustain the strategy, and
2. Erosion in the value of the strategic advantage with industry evolution.

Cost leadership imposes a severe burden on the organization to keep up its position. It means the organization has to reinvest in modern equipment so as to keep reaping all the economies of scale. In addition, it must keep honing its process engineering core capability. Similarly, differentiation requires investments in a strong R&D on a continuous basis and the ability to attract the right type of people into the company. A summary of the risks for the different strategic options is given in Table below:

Table 2.2: Risks of Generic Strategies

Generic Strategy	Risks
Cost Leadership	- Technological change that nullifies past investments or learning. - Low cost learning by industry newcomers or followers through imitation or their ability to invest in state-of-the art facilities. - Inability to see required product or marketing change because of attention placed on cost. - Inflation in costs that narrow the firm's ability to enough of a price differential to offset competitor's brand image or differentiation.
Differentiation	- The cost differential between low cost competitors and the differentiated firm becomes too great to hold brand loyalty. - Buyer's need for the differentiating factor falls. This can happen when the buyers become more sophisticated. - Imitation narrows perceived differentiation, a common occurrence as industries mature.
Focus	- The cost difference between broad range competitors and the focused firm widens to eliminate the cost advantages or differentiation achieved by the focus. - The differences in desired product or services between the strategic target and the market as a whole narrows. - Competitors find niche markets within the strategic target and out focus the focuser.

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A business must adopt a strategy that enables it to secure the resources needed to effectively remain at the cutting edge of technological advances in the pursuit of creating and retaining the customers the firm wants. This is the first requirement. History is rife with firms that failed to see new technologies coming. In his book, *The Innovator's Dilemma*, Professor Clayton Christensen helps explain why first rate companies that listen to their customers are not able to respond to new competitors who use "disruptive" technologies.

Christensen uses the example of the diesel locomotive to illustrate how disruptive technologies "sneak up" until it is too late for the previously dominant firms to respond. When the diesel locomotive was introduced, it did not match the performance of the steam locomotive. Baldwin, the leading locomotive manufacturer, scoffed at this upstart and proclaimed, "They will never replace the steam locomotive"! This was true for some time, but little by little, diesel locomotives improved and before Baldwin knew it, by 1950 diesels had the lion's share of the market. By then, it was too late for Baldwin to respond.

Second, 'competitive advantage' is also created when resources and capabilities owned exclusively by the organization can generate unique core competencies. This advantage is sustainable due to the lack of substitution and imitation capacities by the organization's competitors. As the core competencies are unique, the benefits derived from these advantages are retained inside the organization—they are not appropriated by others.

Finally, competitive advantage can come from a strong and supportive value chain. The members of the chain look at the benefits that accrue to the entire value chain. Such cooperation is possible and often seen in such value chains, e.g., increasing productivity, reducing stocks at different levels, or process improvements, etc., are undertaken by members of the value chain and the advantages that accrue benefit all members of the value chain. In addition, it is able to provide greater value to the customer.

TI Cycles and Hero Cycles: Before, we discuss competitive strategies let us review the strategies adopted by TI Cycles and Hero Cycles. TI Cycles looked at itself basically as manufacturer of bicycles. In 1962, TI Cycles had a capacity to manufacture 300,000 bicycles and Hero Cycles had a capacity of 25,000. In 1999, TI Cycles had increased its capacity to 25,20,000 bicycles while the capacity of Hero Cycles had increased to 47,00,000. Both companies followed concentration strategy. While Hero Cycles invested in assembly plants, TI Cycles manufactured all or most of the components in-house. The investments that TI Cycles made were large in comparison to Hero Cycles. The risks involved in building of additional capacity were much higher for TI Cycles.

However, TI Cycles created for itself a high level of competency in R&D, quality and design in the manufacture of bicycles. Due to this, their product development focus was on internal developments, while Hero Cycles used a strategy of collaborative development for its new products. The result was that they were faster to market in bringing new products, which gave them a competitive advantage.

TI Cycles adopted a strategy of concentric diversification and vertical and backward integration. It invested in steel tubes and strips, cycle chains, and its own components. It also invested small amounts in related businesses like door frames for cars, shutter products and auto components.

Unlike TI Cycles, the Hero Cycle considered itself in the transportation business. Therefore, it diversified into other areas in the automotive space. This can be seen from listing of its group companies; Hero Honda Motors Limited, Hero Cycles Limited, Hero Auto Limited, Munjal Showa Limited, Majestic Auto Limited, Hero Exports, Munjal Auto Industries Limited, Sunbeam Auto Limited, Munjal Castings, Highway Industries Limited, Rockman Cycle Industries Limited, Hero Cycles Cold Rolling Division, Munjal Auto Components, Satyam Auto Components

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Limited, Hero Global Design, etc. The group maintained its policy of minimizing risks by spreading it through developing and promoting ancillary units to support its production programs.

TI Cycles followed a differentiation strategy while Hero Cycles followed a strategy of cost leadership as the competitive strategy. Both companies were extremely good in following the strategies that they had adopted. Since TI Cycles had started the cycle industry in India, the general psychology inside TI was that their leadership 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. What TI Cycles lost track of was that the price conscious segment was growing much faster than the quality, durability conscious segment. When TI Cycles recognized its position, they found that they had not developed the competencies or the network to compete effectively in the price conscious segment. This enabled Hero Cycles to strengthen its position and the TI Cycles got marginalized and was almost forced to vacate many of its traditional markets, and became a sick company.

There are several generic components of a healthy company—a robust and credible strategy based on market realities; productive, well-maintained assets; innovative products, services, and processes; and a fine reputation with customers, wholesalers, dealers, governments, and other stakeholders.

Thinking about health, as opposed to the technical sophistication or quality of the product or service, helps managements understand how to look after companies today in a way that will ensure that they remain strong in the future. It focuses the mind on what must be done today to deliver the outcome of long-term performance. Companies not focusing enough on managing the health of their businesses often lose out, as was the case with TI Cycles.

Self Assessment

Fill in the blanks:

5. The 'low-cost producer' strategy works best when buyers are large and have significant …… power.
6. Successful differentiation creates …… against the five competitive forces.
7. The generic strategy of focus rests on the choice of a …… competitive scope within an industry.

2.3 The Richardson, Taylor and Gordon Framework

As is apparent from many situations in the real world, operations strategies do not fit in neatly with the three generic strategies of Porter. Another way of looking at operations strategy has been suggested by Richardson, Taylor and Gordon. They have developed a six-element framework for operational strategy. Their framework is described below:

2.3.1 Technology Frontiersman

The strategy is to remain at the leading edge of technology with a focus on product innovations. Technology Frontiersmen take advantage of the initial high margins of new product offerings and move on to newer products when the product or service begins to draw tough price competition, or a host of imitators.

Innovation, flexibility and quality are the major components of the value creation logic. The production system has to have the organizational structure and controls to deal with the continuing

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flow of new products of high quality. The design of jobs and work systems is of crucial importance. The focus is on people.

Examples: Hewlett Packard, Oracle, etc.

2.3.2 Technology Exploiters

Though the strategy is to introduce a stream of new products or services, the objective is to exploit the potential large volume market, which may follow the new product introduction. The organization, therefore, from the inception focuses on production design as well as product performance. The major components of the value creation logic are flexibility as well as low cost production. Productivity, process technology, and logistics are critical to this type of organization.

Examples: Microsoft, Texas Instruments, etc.

Though TI Cycles also falls in this category, they were servicing a market that was diminishing in size. Sadly, they were unable to provide value to the customers in the growth market which was constituted primarily of customers for cost minimizers.

2.3.3 Technological Serviceman

This is a strategy of technological leadership in custom service to low volume markets. This often embraces extremely high money values.

Examples: Leading software companies, Infosys, TCS, Wipro, etc.,

They customize and build the specifications of their software to the requirements of their customers. In order to do so, they have to have a highly flexible product development system with extremely high quality requirements. Potential losses to the customer from quality compromises, dominates the strategic choice.

2.3.4 Customizers

The strategy is to build custom designs in low volumes.

Examples: Job shop manufacturers, satellite manufacturers, service organizations like restaurants, etc.

The functional focus is on positioning and the process technology. Often, operating decisions and the supply chain are crucial. The end product is built or delivered to the specifications of the customer. In manufacturing, because of low volumes, numerically controlled machine tools, FMS, and other forms of low volume process technology are often used.

2.3.5 Cost-minimizing Customizers

These organizations deal with products that are mature. The margins are often low but money values are often high. Customers choose the supplier based on specialized skills. Construction companies, shipyards, etc., are examples of this type of organization.

Example: L&T must emphasize flexibility and quality and yet minimize costs, in order to remain a leader in its business.

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2.3.6 Cost Minimisers

These organizations have a strategy of producing standardized, high volume products and services at low costs. There are a large proportion of business models that fall in this category.

Example: Manufacturers of steel, aluminium, cement, etc., who operate in bulk market; fast moving consumer products; services like shipping, airlines, passenger trains, etc.

Hero Cycles also falls in this category. These organizations must be cost competitive and position their product so that it is available in the marketplace, with a controlled and consistent quality.

All the elements of operations strategy have a place in this type of operation. These include positioning, process technology; capacity/location, job design, and operating decisions. Many such organizations are vertically integrated. Advanced techniques of inventory control and process control find an important place in operations in these types of organizations.

Table 2.3: Richardson, Taylor and Gordon Model

Strategy	Description	Value Creation Logic	Functional Focus	Examples
Technology Frontiersman	RD driven; Constant new product introduction; Skimming Profits	Flexibility, Quality, Supply Chain	Positioning, Job Design, Operating Decisions	Hewlett-Packard
Technology Exploiters	New Products, Long-term Perspective; Product development linked with Process Design, Cost competition	Flexibility, Cost, Availability	Positioning, Process Technology, Capacity Location, Operating decisions, Suppliers	Microsoft, Texas Instruments
Technological Serviceman	Custom Service for Complex systems for low volume customers and markets; Excellence in Product Design	Flexibility, Quality	Positioning; Process Technology; Operating Decisions; Supply Chain	Infosys, TCS, Airbus Industrie, Boeing
Customizers	Job shop manufacturing to build custom designs	Flexibility, Quality	Positioning; Process Technology; Operating Decisions; Supply Chain	BARC, Hughes Network Systems, ECIL
Cost Minimizing Customizers	Low volume mature products manufactured to individual customer designs	Cost, On-time-delivery; Flexibility	Positioning, Process technology, Supply Chain	Hindustan Shipyards, L&T
Cost Minimizers	High volume producers of standard commodity type products, long runs of continuous production	Cost, Availability, Quality	Positioning, Process Technology; Capacity/ location, Job design, operating decisions, Vertical Integration	TISCO, NALCO, HLL, Nirma, TI Cycles, Hero Cycles

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Competitive advantage grows out of the entire system of activities. The value creation logic of the organization can be visualized in the value chain. The more integrated the fit in the activities relating to the functional focus are, the more effective is the strategy and the more difficult is it to be copied by competition. In assessing its competitive strategy, the firm must focus on those value creating attributes that its customers look for in the product and which the firm is capable of delivering better than others. The value creation logic should be such that competitors will find that they cannot easily replicate the value provided by the firm.

Task Take an organization with which you are familiar, and use relevant tools and frameworks to identify and assess the potential sources of competitive advantage.

Self Assessment

Fill in the blanks:

8. Cost Minimiser organizations have a strategy of producing……, high volume products and services at low costs.
9. Technological Serviceman is a strategy of technological leadership in custom service to …… markets.
10. Innovation, flexibility and …… are the major components of the value creation logic.
11. …… strategy is to build custom designs in low volumes.

2.4 Translating Strategy into Operational Effectiveness

OM is linked directly with many initiatives that firms use to sustain and revitalize competitiveness. These include such approaches as rapid product development, process improvement and total quality, lean production, and supply chain management. As the workplace becomes more flexible, as Information Technology (IT) and e-commerce permit new and innovative work arrangements, and as customers become more demanding, OM will continue to play a significant role from a strategic business perspective.

Value is a core concept in a business's strategy because it directs organizations to strive to understand the customer buying process. People part with their money to buy a product when it delivers more "value" than the value they attribute to the money exchange.

The value model assumes that a customer elects to purchase a product when a need exists and when the core and augmented benefits derived from making a purchase exceed the product's cost. The ultimate driver for all activities done within the organization is to satisfy the targeted customer. The product should also offer more value than the competitor's product.

This must be the primary way in which the organization views the marketplace and be a determinant of strategy. The strategy tells the operations function:

1. Who the targeted customers are and what they want,
2. Estimates the size of the market and the anticipated distribution of customers, and
3. Profiles how the firm intends to compete to win these customers.

The rapid changes in the competitive environment, reflected by clock-speed, are having a major impact on strategy formulation and the competitive environment. There are three forces that are the major drivers of these changes.

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Information technology provides vast new ways to communicate—both within operations, such as having machines talking to machines, and between the players within the firm's supply chain, such as B2B (business-to-business) vendor management software. B2B supply chain management tools that use information technology to enhance the flow of materials within the supply chain are being adopted by many organizations. Traditional 'purchasing' may continue to exist, but the roles of humans within e-purchasing systems will be dramatically different. This is the first force.

The second force is the market's demand for product customization. Customers can participate in leading edge firms' product innovation process.

Example: Maruti Udyog Limited, the premier automobile manufacturer in India, has responded to the changing competitive conditions in the market. In a bid to retain its premier position in the market, it is offering customization for its basic car model, the Maruti 800, even before consumers have demanded it. This includes basic face lifting to a completely colour coordinated version. The customer has been offered a choice of colour combinations, material and functionality add-ons. The facility is available on new purchases. It is also available for in-use cars so that the company retains the goodwill of its existing customers.

Customization has increased in importance as economies of scale no longer induce manufacturers to make standard products using standard parts.

Example: Sundaram Fasteners Ltd. has split its earlier integrated manufacturing system into smaller production modules. The company calls these 'zones of autonomous production'. These have enhanced worker skills on the one hand, and the company's flexibility on the other.

The third major force impacting operations managers is increased globalism-especially within the firms' supply chain. This has been instrumental in creating a new production system of "worldwide sourcing" which is now a foundation of the new world economy. Instead of simply operating plants abroad, multinationals integrate those plants that manufacture their components as subdivisions of a globally organized production process.

Example: General Motors sources its components from as many as 50 countries. Its radiator caps are supplied by Sundaram Fasteners.

Globalism also impacts the services sector. A small security set up in Hyderabad is providing security services for a number of large integrated office complexes in New York, though it has placed no security personnel in the U.S.A. Another example is the emergence of India into a major player in software development. Infosys, NIIT, HCL, etc., are primarily offering their services in offshore markets. They service clients such as Ford, General Motors, GE, Unilever, etc.

2.4.1 Implementing Strategy

Implementing the operations strategy involves the organizing, directing/implementing, and controlling the different facets of management effectively. This process is difficult since it requires top management to secure and manage the resources needed to actually achieve the business strategic objectives: managers who can faithfully translate the thoughts of top management, and job workers who have the skill and motivation to deliver the results.

At slow clock-speeds, the means used to deploy and implement a corporate strategy throughout a firm can be policy driven. As one moves down through an organization, each level down can define what its function needs to do to support the firm's efforts to achieve its strategic goals.

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First you define the sub-goal, then install business processes capable of achieving these goals, and lastly you measure how well each business process contributes to achieving the business unit's objectives.

But at high clock-speeds, a top down approach to strategy implementation often fails because it can't respond quickly to unforeseen opportunities and threats. In such cases, the organization design must provide the firm's units broad strategic guidelines and then empower the units to do that which is necessary to contribute to achieving its goals. In the faster lane, people become more important than policy. This reality is true for each of the firm's functional areas, but it is especially true for its operations management function.

Once the strategy is finalized, it has to be implemented through the functional areas. The operations managers must translate the strategy by working out the details of how it can or should be executed. Implementing business strategy is often problematic. The firm's expectations provide the basis for evaluating the effectiveness of management.

Implementing strategy is normally considered through a systems perspective that views management as a three-stage process. In business environments where the change of pace is not very fast, this approach to strategy implementation works well. The three stages are described below:

1. ***The Organization Level:*** This reflects the competitive strategy of the organization. It uses the corporate strategy as an input and then converts it into a broad description of how senior management wants the firm and its units to be run. Outputs of this level include:

   (i) *Organizational Objectives:* The objectives define how the firm intends to achieve and maintain its desired competitive advantage as well as how the firm intends to benefit from said advantage, i.e., how much sales, market share, and earnings are expected. Organizational goals also include qualitative objectives, involving things such as repeat sales, service levels, awards, prestige, etc.

   (ii) *Organization Design:* This defines the arrangement of the units to implement the strategy. It involves both physical entities such as plant and equipment, the organization structure, and how it expects to treat/reward its people for performance.

   (iii) *Organizational Management:* The specific objectives for each group are translated into measures to evaluate their performance, formulate a resource management plan, and develop an understanding of how the groups will interact with each other.

2. ***The Process Level:*** This is the level at which units actually do the work. From the organizational level, the strategy has to be translated for each individual process. Processes include such activities as order entry, product innovation, and the actual making of the product. The process level can again be broken down to specific sub-systems:

   (i) *Process Objectives:* These are measurable objectives for each of the processes.

   Example: Manufacturing might be expected to translate customer orders into products within six working days of being communicated to them.

   Process objectives can be multi-dimensional, i.e., a production process might be evaluated on the basis of cost, product quality, and on-time delivery reliability.

   (ii) *Process Design:* In order to achieve the process objectives, it may be necessary to design or redesign processes. The objective is to provide each person with a work situation that can be done effectively when given proper guidance and adequate resources.

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(iii) *Process Management:* This involves translating process objectives into specific sub-objectives for its subgroups and metrics to evaluate their performance. The idea is to make sure that the way in which the process is managed is able to achieve process objectives.

3. ***The Job/Performer Level:*** Each process is a collection of jobs. The jobs that have been identified need to be performed effectively. In order to do so effectively, jobs are broken down into activities. These are the basic units of implementation. These need to be organized and directed so as to provide control to the management process. The activities of the job are broken down to include the following tasks:

   (i) *Job Objectives:* Here we establish objectives for the people staffing the process.

   Example: In a restaurant a waiter might be expected to serve five tables an hour during the peak shift-with minimum customer complaints.

   (ii) *Job Design:* Managements' task is to figure out what that way is and then to train employees to do each task in the right manner. However, employees need to feel responsible for the appropriateness of their jobs. Job design is successful if it planned within the context of the organization's culture.

   (iii) *Job Management:* The manager must manage each employee in a way that enhances the likelihood of the task being performed effectively.

Fast pace businesses are not fast pace in all areas. The trick is to identify those areas that are not fast and use the same system to implement strategy. In faster paced activities, it pays to do as much of the work using the 'best practices' approach. Best practices work well on repetitive problems. This allows the organization to focus its scarce talent on future opportunities and non-recurring problems.

Self Assessment

Fill in the blanks:

12. Implementing strategy is normally considered through a systems perspective that views management as a …… process.
13. The …… Level is the level at which units actually do the work.
14. The firm's …… provide the basis for evaluating the effectiveness of management.
15. Implementing the operations strategy involves the organizing, directing/implementing, and …… the different facets of management effectively.

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

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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 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

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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 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

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Notes

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.

Source: Upendra Kachru, *Production and Operations Management – Text and Cases,* First Edition, Excel Book, New Delhi, 2007.

2.5 Summary

- The objective of operations strategy should be to give the firm a competitive advantage.
- Performance depends on the functionality, quality, speed, timeliness, and flexibility of the product offering.
- The business strategies are basically competitive strategies whose objectives are about how to compete successfully in particular markets.
- A firm pursuing a cost-leadership strategy attempts to gain a competitive advantage primarily by reducing its economic costs below that of its competitors.
- In a differentiation strategy, a firm seeks to be unique in its industry along some dimensions that are widely valued by buyers.
- The generic strategy of focus rests on the choice of a narrow competitive scope within an industry.
- Richardson, Taylor and Gordon have developed a six-element framework for operational strategy. Their framework elements are Technology Frontiersman, Technology Exploiters, Technological Serviceman, Customizers, Cost-minimizing Customizers and Cost Minimisers.
- Implementing the operations strategy involves the organizing, directing/implementing, and controlling the different facets of management effectively.
- Value is a core concept in a business's strategy because it directs organizations to strive to understand the customer buying process.
- Implementing strategy is normally considered through a systems perspective that views management as a three-stage process which are at Organization Level, Process Level and Job/Performer Level.

2.6 Keywords

Corporate Level Strategies: Strategies that are concerned with the broad and long-term questions of what business the organization is in or wants to be in, and what it wants to do with those businesses.

Flexibility: It is the ability of the OM system to give the customer the product desired.

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***Functionality*:** It is a measure of the extent the product, when properly used, is able to accomplish the intended use.

Generic Competitive Strategies: Competitive strategies that can be used by the organization to outperform competition and defend its position in the industry.

Quality: It is broadly defined as the extent to which a good or service is delivered consistent with what the customer has been led to expect.

***Speed*:** It is a measure of how long a customer must wait for the product once it is requested, and how long it takes to design, develop, and introduce new products.

2.7 Review Questions

1. Explain the important issues associated with the key decision areas in Operations Management.
2. What are some of the current challenges that operations managers face in each decision area?
3. To what extent will the sustainability of competitive advantage depend upon the organization's strategic capabilities or its position within the industry?
4. What are the three generic strategies with which operations strategy must be consonant?
5. 'The scope of Operations Management encompasses value creation and support processes and is best explained by the types of decisions that operations managers face'. Explain.
6. 'As a developed nation becomes more industrialized, people gain in skills and affluence. Many more people enter the labour force and very often, both the spouses are working'. How do these changes reflect on the role of the operations manager? Explain.
7. How do the three generic strategies differ and provide 'competitive advantage'?
8. 'Some say that, Porters' Generic Strategies reflect the concerns of OM better than the framework developed by Richardson, Taylor and Gordon'. Do you agree? Give reasons for the position you take.
9. From the point of view of the Operations manager, what would you do in changing market conditions? Would you adapt your operations capabilities or find new markets to fit your existing capabilities? Explain.
10. Is it important to understand the complex tradeoffs involved in operational decisions as well as how the different decision areas may be affected by such decisions? Give reasons to support your answer.

Answers: Self Assessment

1.	value equation	2.	lower
3.	stream of income	4.	value
5.	bargaining	6.	lines of defense
7.	narrow	8.	standardized
9.	low volume	10.	quality
11.	Customizers	12.	three-stage
13.	Process	14.	expectations
15.	controlling		

Notes

2.8 Further Readings

Books

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

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

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Unit 3: Services and their Characteristics

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Objectives

Introduction

3.1 Meaning and Characteristics of Services

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Objectives

After studying this unit, you will be able to:

- Explain the meaning and characteristics of services;
- Describe the service matrix;
- Discuss the management of service quality;
- Recognize the role of services in economy.

Introduction

There are growing sectors like retail, telephony and Internet service provider companies, business process and knowledge process outsourcing companies, e-service providers who are termed as emerging service sectors. A set of service providers developing and providing services to companies, business houses and manufacturing sectors are called 'business service provider', and those providing services to individual customers are called 'consumer service providers'. However, a product, which is offered to business offer is a combination of product and accompanying services. It is very difficult to separate a company as a pure product or service company in today's economy. A complete product or individual customers, is always accompanied by services.

3.1 Meaning and Characteristics of Services

A service is defined as any activity or benefit that one player offers to another in an exchange process, which is essentially intangible and does not result in ownership of anything.

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Its production may or may not be tied to a physical product. Many manufacturers, distributors and retailers offer value added services to differentiate their offer from others. There are many pure service firms who use Internet and e-commerce technology to reach customers.

A pure service has a set of distinctive characteristics that differentiate them from pure goods or product manufacturing companies in ways having implications for marketing. These characteristics include intangibility, inseparability, variability, perishability and inability to own a service.

Intangibility

A pure service is difficult to assess through any of the physical senses. It is a bundle of abstractions, which cannot be assessed before it is owned. A potential customer can physically examine all the alternative products in the market before making a choice. He can use criteria like packaging, aesthetic appearances, taste and smell before making a choice. Many of the benefit claims made in advertising can be evaluated before making the purchase decision. Pure services do not have any tangible properties, which can be used as evaluative criteria by consumers before making a brand choice.

The intangible characteristics that define services include reliability, care and empathy. Attentive behavior of serving staff can be verified only after the service is purchased and during consumption. Measurement of service quality is comparatively difficult in pure service cases. Products in the store have tangible, standardized, physical elements through which they can be evaluated. In contrast to this, benchmarks for services are embedded in customer's mind and have to do with the service provider's image. Today products are evaluated by comparing with associated services. Hotels are standardized with star facilities like five star, three star due to a combination of tangible and intangible factors like location, facilities, number of people serving per room, the physical ambience and other associated tangible factors. The presence of tangible components helps customers to evaluate hotels and restaurants on the basis of evident visibility. There are less tangible services like life insurance where visibility does not augment the service evaluation.

Intangibility implies lack of physical evidence, which brings uncertainty in the minds of consumers while making a decision. So, an important task of any service marketer is to create physical evidence to reduce uncertainty level in consumer's mind. Developing good physical evidence and building a strong brand can augment the tangibility component of a service.. While a service marketer tries to augment the service with tangible physical evidence, the product marketer augments the tangible product with intangible services like after sales service, warranty and guarantee schemes to enrich the customer experience.

Did u know? Pure goods and pure services move in the opposite direction in terms of the general approach to tangibility.

Inseparability

Services cannot be separated from the source. The production and consumption of goods are two separate activities. Companies produce goods in their manufacturing facilities and distribute them at retailer's point for consumption. Products can be separated from the source of manufacturing. Product marketing companies can achieve economies of scale through centralized production and can have centralized quality management programs. The marketer can market the product and the consumer can consume it at their convenient time. So production and consumption are two separate issues in product marketing. Quite contrary to this, the consumption of services is inseparable from its source of production. In order to realize the benefits of

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services, the producer and the consumer must meet and interact at the time of consumption. Both must normally meet at a convenient time when the producer can pass on the benefit to consumers. In personal care services, the consumer must be present during the entire production process e.g. a patient has to be there while a surgeon is performing a surgery. Inseparability happens in both the cases when the service is provided by a human being or by a machine. The services of a machine can only be realized when the consumers interact with the machine. Due to changes in information technology, it is possible to geographically separate the producer and the consumer of a service e.g. a banking service is possible through Internet, ATM, kiosks and mobile or tele-banking facilities due to low level of personal contact.

Inseparability has its own marketing implications. In a manufactured good consumption process, the product can be produced, distributed, inventoried at retailer point and can be consumed after procurement and stored for consumption. Inseparability causes a modification to the service consumption process. They are generally sold first, then produced and consumed simultaneously. While the method of producing a good is of little relevance to the consumer, production process of services is critical for customer satisfaction. In the goods marketing, they are not part of the production process and they are satisfied if the product meets their expectations. In the services marketing, since the consumer is a part of the production process, the process is as important as the end service. So in some instances, a small change in the quality level of the production process may totally destroy the value of the service.

Variability

Mass produced goods and services can be standardized and the current age is the age of standardization. But in case of services like airlines, legal advice and financial services, it is very difficult to keep the services consistent and standardized. Variability in services has an impact not only on customer satisfaction but also in the production process of services. As the customer is involved in both production and consumption process at the same time, variability has a greater impact on services marketing. It is very difficult to monitor and control services for consistency and standardization. The opportunity for pre-delivery inspection and rejection of products is possible in manufactured goods but is impossible in services.

Variability in production standards is of greatest concern to service organizations where customers constitute an important part of production process. This is true in cases of labor-intensive services. There is a higher scope for quality control in machine-based services during its production, e.g. telecommunication and mobile services can operate at a very low failure rate. The equipment-based services are less variable than human-based services. Today, interactive voice response systems and virtual representatives on Internet are providing better customer service than human operators. The variability of service output poses problems for brand building. It is easy to incorporate monitoring and quality control systems to manufacturing processes for measuring consistency in output. This consistency is the 'brand promise' for a manufactured product. To reduce variability in services, marketing managers should try to simplify jobs, automate jobs by substituting interactive machines in place of human service providers.

Did u know? **What are hybrid services?**

Hybrid services like restaurants where both product and service are important.

Perishability

Manufactured goods can be stored for future consumption whereas services cannot be stored. It is possible for the manufacturer to store and manage inventory levels to suit different market situations and demand patterns. The services in contrast neither can be stored nor can be carried

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forward. If few seats are lying vacant in an aeroplane, they cannot be stored or carried forward for the next trip. There are very few services with a constant demand pattern over a period of time. Many show considerable variations due to seasonal and cyclical nature of the service demand and also due to unpredictable demand patterns. The perishable nature of service demands greater attention to demand management of a service.

Notes The service marketer will like to smoothen the troughs and crests in demand patterns and schedule production processes of services in such a way that there is an optimal consumption at the point of production and consumption of that service. The demand and supply patterns should match both in short term and long term by using pricing and promotion tools to resolve demand-supply imbalance. Airlines offer discounted fares before departure to maximize the benefits of supply by offering tickets at a low price.

Inability to Own Services

This characteristic of not owning a service emanates from the characteristics of intangibility and perishability. The buyers can acquire title of goods in a transaction process and continue to do so as and when they wish. On the other hand, when a service is performed, no ownership is transferred from the seller to the buyer. The buyer is only buying the right to a service process. So there is a difference between inability to own the service and the rights a buyer may acquire to have a service carried out at sometime in the future. This aspect has an implication for distribution of services. A wholesaler or a retailer cannot take a title, contrary to the case with goods. So direct distribution methods are more common and wherever intermediaries are used, they are used as co-producer or co-creator of value for the consumer.

Task The degree of intangibility and inseparability are the true crucial issues in service marketing. Explain how these two factors influence marketing of a large corporate hospital.

Self Assessment

Fill in the blanks:

1. The intangible characteristics that define services include reliability, care and ……
2. The perishable nature of service demands greater attention to …… management of a service.
3. Variability in services has an impact not only on customer satisfaction but also in the …… process of services.
4. A service is defined as any activity or benefit that one player offers to another in an exchange process, which is essentially …… and does not result in ownership of anything.
5. The aspect of inability to own services has an implication for …… of services.

3.2 Service Matrix

The Service Process Matrix is a categorization matrix of service industry firms based on the characteristics of the individual firm's service processes. The matrix was derived by Roger

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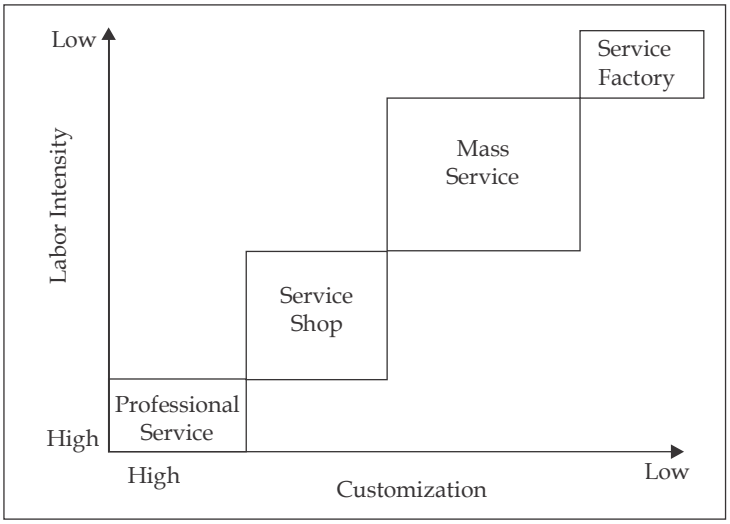
Schmenner and primary appeared in 1986. Although considerably different, the Service Process Matrix can be seen somewhat as a service industry version of Wheelwright and Hayes' Product-Process Matrix. The Service Process Matrix can be helpful when investigating the strategic changes in service operations. In addition, there are unique managerial challenges connected with each quadrant of the matrix. By paying close attention to the challenges associated with their related classification, service firms may perk up their performance.

The classification characteristics take in the degree of labor intensity and a jointly measured degree of customer interaction and customization. Labor intensity can be described as the ratio of labor cost to plant and equipment. A firm whose product, or else in this case service, requires a high content of time and effort with comparatively little plant and equipment cost would be said to be labor intense. Customer interaction symbolizes the degree to which the customer can intervene in the service process.

Example: A high degree of interaction would mean that the customer can demand more or less of some aspects of the service.

Customization refers to the need and ability to alter the service in order to please the individual customer's particular preferences.

Figure 3.1: Service Process Matrix



Source: http://www.slideshare.net/taquilla/operations-management-919-slides-presentation

The vertical axis on the matrix, as shown in Figure 3.1, is a range with high degree of labor intensity on one end (bottom) and low degree of labor intensity on the other end (top). The horizontal axis is a range with high degree of customer interaction and customization on one ends (right) and low degree of customer interaction and customization on the other end (left). This results in a matrix with four quadrants, each with a exclusive combination of degrees of labor intensity, customer interaction and customization.

The upper left quadrant includes firms with a low degree of labor intensity and a low degree of interaction and customization. This quadrant is labeled "Service Factory." Low labor intensity and slight or no customer interaction or customization makes this quadrant similar to the lower right area of the Product-Process Matrix where recurring assembly and continuous flow processes are located. This allows service firms in this quadrant to operate in a fashion alike to factories, hence the title "Service Factory." These firms can take advantage of economies of scale and may

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employ less expensive unskilled workers as do most factories. Firms categorized as service factories include truck lines, hotels/motels, and airlines.

The upper right quadrant includes firms with a low degree of labor intensity but a high degree of interaction and customization. The upper right quadrant is labeled "Service Shop." Hospitals, auto repair shops and lots of restaurants are found in this quadrant.

The lower left quadrant includes firms with a high degree of labor intensity but a low degree of interaction and customization. This quadrant is labeled "Mass Service." Mass service providers contain retail/wholesale firms and schools.

Lastly, the lower right quadrant includes firms with a high degree of labor intensity and a high degree of interaction and customization. The lower right quadrant is labeled "Professional Service." This quadrant is alike to the upper left section of the Product-Process Matrix where job shops and batch processes are found. Doctors, lawyers, accountants, architects, and investment bankers are usual service providers that tend to be labor intense and have a high degree of customer interaction and customization.

In 1994, Dotchin and Oakland projected that in addition to the four categories: service factory, service shop, mass service and professional service, a fifth category should be added: personal service. They rationalize the inclusion by describing personal services as those directed at people, thereby high contact, as opposed to professional services which are bound for to things, thereby, achieved with little contact time.

Self Assessment

Fill in the blanks:

6. Service Process Matrix can be helpful when investigating the ……..changes in service operations.
7. …….can be described as the ratio of labor cost to plant and equipment.

3.3 Managing Service Quality

Customers test the quality of service of a firm at every encounter. Each of the customer encounters is called 'moment of truth' and a series of moments of truth lead to a relationship. If the experience from service encounters are bad, it may not lead to customer satisfaction. Management of service quality is a growing concern for a service marketer. Quality management involves deciding on quality standards and implementing a method of assurance on performance level of the staff and the facilities. Quality has emerged as a major competitive element in service company strategies. Service providers are giving increasing emphasis on creating reputation for good quality of service as this provides a positive image for their organization.

Caution It must be kept in mind that if quality people leave the organization, the entity and quality of the service is affected, dampening company's overall image.

The service quality management process involves matching evolving customer expectations. Customers have their own service expectations from a firm. A customer is satisfied when his expectation match the perceived service. When the perceived service passes over the expected service, the customer is delighted. Failure in meeting expectation results in customer dissatisfaction, complaint and withdrawal of the service consumption. There are three reasons for the increasing relevance of quality management in services sector as mentioned in the Box 3.1.

Notes

Box 3.1: Increasing Relevance of Service Quality Management

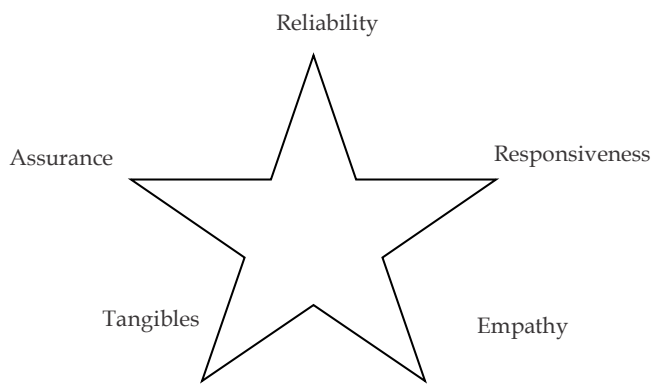
1. Companies need to find ways of creating differential advantage by having better service levels than their competitors.
2. Increased level of consumerism and greater media attention on quality have meant that companies have to be more responsive to quality issues.
3. There has been a growing sophistication of consumer markets, with the non-price factors of image, product positioning and service delivery processes becoming more important.

A reputation of good quality is a major advantage because perception of risk for many service providers is very high. Good quality bridges the gap between pre-use perceptions and post-use experience of the service consumed.

Notes Five Stars of Service Quality (The RATER Model)

- Reliability
- Assurance
- Tangibles
- Empathy
- Responsiveness

Figure 3.2: Five Stars of Quality



The service providers are more likely to be successful if they can be depended upon to deliver high quality service with respect to the quality determinants as mentioned above in relation to competitors. Quality management approach can be divided into two categories, namely *product attributed approach and customer oriented approach.*

3.3.1 Product Attributed Approach

In product-attributed approach, customers try to judge the product's conformance to standardized requirements, which have been set by reference to what company managers think the failure point is. In this approach, organizations try to control their products using an internal product perspective e.g. a manufacturer of potato chips can grade pieces of potatoes received from the supplier according to certain objective criteria. These criteria can be weight, shape, size, color, texture etc. From the consumer's point of view, as an external perspective, assessment of quality

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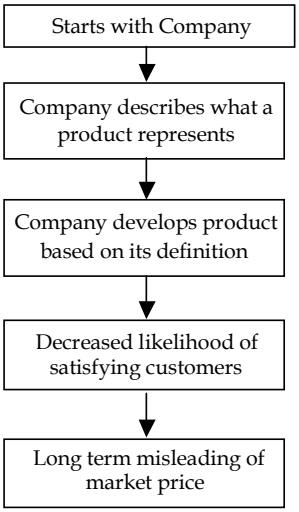
can be made at the supermarket or vegetable store prior to purchase. Consumers can touch or feel goods at a more subjective level. But in both cases, the assessment of quality relates to the finished product. This involves *inward* looking product-led approach. The product-attributed approach focuses on eight elements: Performance, Features, Reliability, Conformance, Durability, Serviceability, Aesthetics and Perceived Quality.

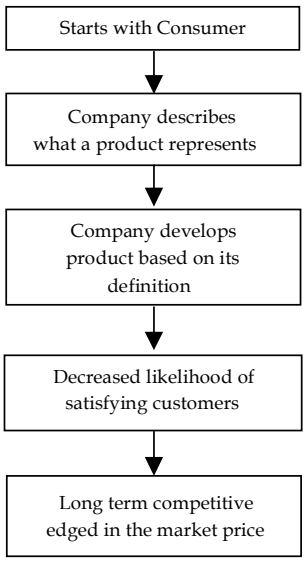
Figure 3.3: Product Attributed Approach



3.3.2 Consumer Oriented Approach

This approach may also be termed as user-based approach. This approach starts from the premise that quality *"lies in the eyes of the beholder"*. It is, therefore, more appropriate to adopt a consumer-oriented approach, which recognizes that the holistic process of service delivery has to be controlled by taking into consideration the expectations and attitudes of service clients. Goods that satisfy customer preferences best are believed to have high quality. The major problem with customer-oriented approach is the equating of quality with maximum satisfaction.

Figure 3.4: Consumer Oriented Approach



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A consumer may enjoy a particular brand because of its unusual taste or features; and yet he may regard some other brand as being of higher quality e.g. you may enjoy *Dosa* at Karnataka Restaurant but still feel that the one at Sagar Ratna is the best. This highlights that customers make judgments about the quality of service delivery process as well as the final outcome. The independent businessman might assess the quality of the consultant's work not only on the final appearance of the techno-economic feasibility report but also on the way the employees of the organization respond to the queries and the speed with which the work is being performed.

A service is made up of tangible and intangible components. Researchers have made attempts to define service quality and in the process have made distinction between objective measures of quality and subjective measures of quality. According to Gronroos, a service can be broken down into two components, namely technical quality and functional quality; both the dimensions are relevant to customers. For a service provider, it is the starting point to know how quality is judged by customers and what are perceptual processes of this judgment towards the quality of service experienced.

Table 3.1: Two Dimensions of Quality

Component	Definition	Example
Technical Quality	Relates to quantifiable aspects of service i.e. 'what' is being done. This aspect can be accurately measured.	In case of repair of car, customer may look at the equipment and machinery being used to repair the car.
Functional Quality	Relates to 'how' technical quality is being delivered to consumer. This aspect cannot be as accurately measured.	The general attitude, behavior, appearance, dress code of the employee may be instrumental for functional quality being delivered.

Whatever approach we may take to define quality, most researchers are of the view that it is the customer who defines quality.

Task How is it possible to manage quality of service for a firm, which has wider and deeper service mix? Take the case of a multiple service provider like ICICI Bank and explain various service levels.

Self Assessment

Fill in the blanks:

8. In ……approach, customers try to judge the product's conformance to standardized requirements, which have been set by reference to what company managers think the failure point is.
9. Service providers are giving increasing emphasis on creating reputation for good quality of service as this provides a ……..for their organization.
10. Quality management involves deciding on quality standards and implementing a method of ……on performance level of the staff and the facilities.
11. ……..approach starts from the premise that quality *"lies in the eyes of the beholder"*.

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3.4 Dimensions of Service Quality

Quality is a concept related to the attitude of the customers and their comprehensive evaluation of the service. It is built upon a series of evaluative experiences of the services delivered by the organization to the customers. The service quality can only be accessed after the service is consumed. The assessment of service quality is made during delivery of service when customer encounters the service personnel. Customer satisfaction with service quality is defined by comparing perceptions of service received with the perception of expected service of the consumers. When the expectations exceed, service is perceived to be of exceptional quality and gives a pleasant surprise to the customer.

Dimensions of service quality refer to the elements which customers judge as relevant in developing a good quality service. Parasuraman, Zeithaml and Berry suggested that the criteria used by consumers that are important in molding their expectations and perceptions have ten dimensions; each of these dimensions is explained in the Box 3.2.

Caution Firms are require to choose wide or narrow product or service lines on the basis of organizational objectives and capabilities and market expectations.

Box 3.2: Service Quality Dimensions

1. ***Reliability:*** It means ability to provide what was promised dependably and accurately.
2. ***Tangibility:*** It means physical facilities and equipment and the appearance of the personnel.
3. ***Credibility:*** It means honesty and trustworthiness.
4. ***Responsiveness:*** It means the willingness to help customers and provide prompt service.
5. ***Communication:*** It means keeping customers informed in a language that they can understand.
6. ***Security:*** It means physical, financial and confidentiality for the service delivery.
7. ***Competence:*** It means possession of required skills and knowledge to deliver the support services.
8. ***Access:*** It means the ease of approach and contact with the organization personnel.
9. ***Empathy:*** It means degree of caring and individual attention provided to customer's needs and demands.
10. ***Courtesy:*** It means politeness, respect or friendliness in delivering the services.

Subsequent research has reduced these dimensions of service quality to five independent factors namely reliability, responsiveness, assurance (a combination of competence, courtesy, credibility and security), empathy (a combination of access, communication and understanding of customer) and tangibles. There are four key factors that can influence a customer's expectations, which may help customers in shaping their expectations of a service:

1. ***Word of Mouth Communication:*** This is the communication that flows from one person to another in a social loop and helps in formulating service quality perceptions.
2. ***Personal Needs and Preferences:*** The relative importance that the person gives to the service as an essential part of the offer.
3. ***Past Experience:*** The customer expectations also depend upon past experiences of the customer with the service provider.
4. ***External Communications:*** External communications like advertising, public relations and other publicity tools also influence the quality of service perception.

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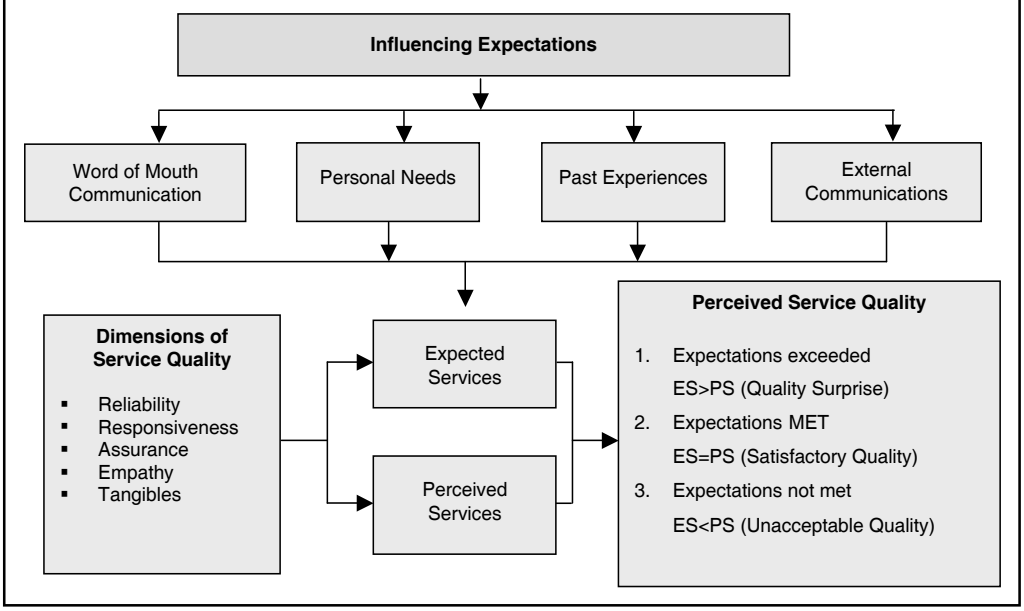
Figure 3.5: Dimensions of Service Quality



There are various issues involved in the quality of service productivity. The managerial task is to transform the service inputs into outputs, to bring a balance between the productivity and quality of services. If the productivity increases then there is a chance that the quality might be compromised. Whether technology is the issue related to delivery of services or the quality of manpower; the service provider will decide the perception of the service. Productivity helps to keep the costs down as lowering prices helps in building the market and competing better. Higher productivity helps in generating additional revenue, which helps in enhancing marketing budget and rising profits, which in turn, helps in investing in innovative service management programs.

Quality helps in gaining competitive advantage through services in a commodity market. It also helps in increasing customer value, which contributes towards improving the bottom line. The service quality is measured using three parameters - efficiency, effectiveness and productivity. Efficiency is a comparison to a standard, which is usually a time-based phenomenon that explains how long the employee takes to perform a service function. Effectiveness is the degree to which the firm meets its goals whereas productivity is the financial evaluation of output to input i.e. consistent delivery of output desired by customers should command higher price.

3.4.1 Gaps in Service Quality Delivery

Leading service and consumer durable companies measure the gap between the customer's service expectations against the perceived services as a routine feedback process. Zeithaml, Parasuraman and Berry developed a model which suggest that customers become dissatisfied when their perceptions about service performance don't match their expectations and the model explains five gaps that can lead to customer dissatisfaction. Expectations are affected by four factors – customer's personal need, past experience with the service providers, word of mouth communication with other customers and communications from service firm and its competitors. What the service provider promised and what he ultimately delivered affect the perceptions of the quality of services. This model identifies five gaps as mentioned in the Box 3.3.

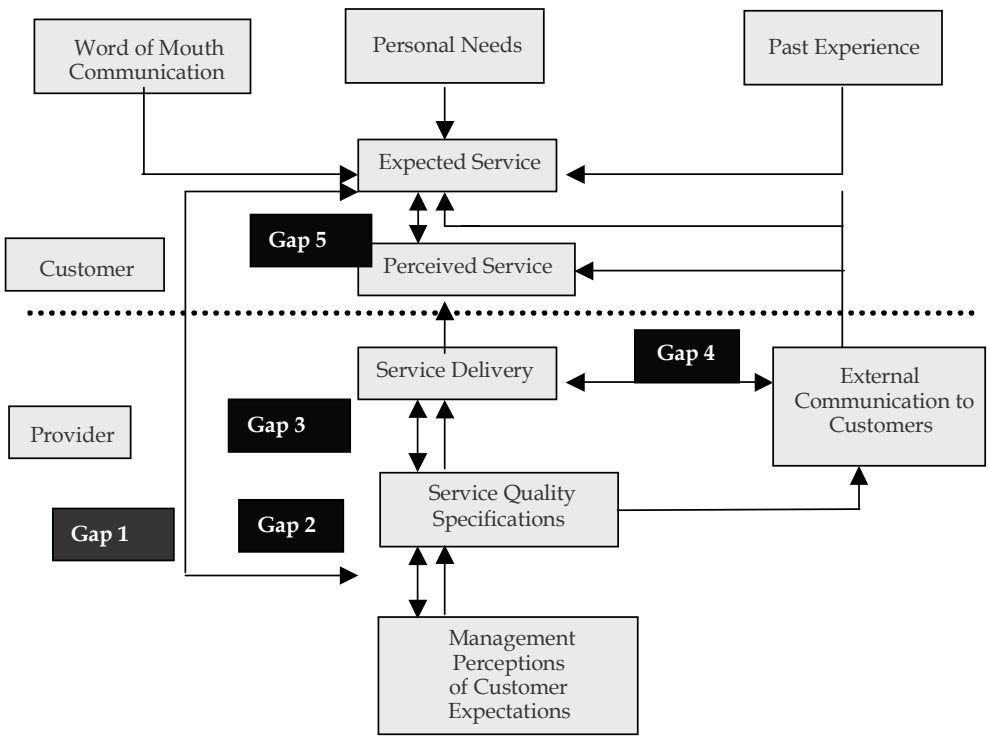
Notes

Box 3.3: Service Quality Gaps

- The service provider does not know what customers expect
- The wrong service quality standards are set
- Standards are not met (Service Performance Gap)
- What is delivered does not equal what was promised
- Gaps 1-4 lead to service that does not equal expectations

The ZPB model is applicable to all service providers and empirical research suggests that organizations should manage to fill the quality gaps in services so that the customer will stay satisfied.

Figure 3.6: Service Quality Gaps



In the Figure 3.6, the gap between customer expectations and perceptions is defined as the Gap-5 and shown to depend on the size and direction associated with the delivery of services. The Gap-1 is the discrepancy between the customer expectations and management perceptions of these expectations. It arises from the management's lack of understanding of how customers formulate their expectations on the basis of a number of sources i.e. advertising by the firm, past experience with the firm and its competitors, personal needs and communication with friends.

Strategies to close this gap include improving marketing research, fostering better communication between management and service employees and reducing levels of management that distance the customer. Gap-2 results from the management's inability to formulate target levels of service quality to meet perceptions of customer expectations and to translate them into workable specifications. It results from lack of management commitment to service quality as a result perception of infeasibility in meeting customer expectations for each of the resources and excessive demand.

Notes

However, setting goals and standardizing service delivery tasks can reduce this gap. Gap-3 is referred as 'service performance gap' because actual delivery of service does not meet the specifications set by management. This can arise because of lack of teamwork, poor employee selections, inadequate training and inappropriate job design and man specifications. Gap-4 is the discrepancy between service delivery and external communications in the form of exaggerated promises and lack of information provided for service personnel. Gap-5 represents key challenges to ensure good service quality. The provider must meet or exceed customer expectations, as perceived service quality is the result of the consumer's comparison of expected service with perceived service delivery. It is possible to identify the service quality gaps in each of these levels and take corrective actions for solving the service quality management problems.

Self Assessment

Fill in the blanks:

12. …… means the willingness to help customers and provide prompt service.
13. Zeithaml, Parasuraman and Berry developed a model which explains …… gaps that can lead to customer dissatisfaction.

3.5 Role of Services in Economy

The service sector has come to stay as one of the key drivers of modern economic systems. While, consumer affluence is propelled by increase in income level, and generation of wealth across majority of industrialized nations, it has also contributed towards growth in services. The service economy contributed more than half of the Gross Domestic Product (GDP) in many of the developed nations. Even in developing countries like India and China, services have emerged as a key sector fuelling growth and success for business houses. Many of the successful manufacturing companies like Tata, Birlas and Reliance have entered into the service business.

The service sector has become more competitive and is posing more challenges to managers to apply principles and strategies to achieve success in the service sector. Deregulation, economic liberalization and rising expectations of consumers have made managers to apply managerial skills, practices and strategies to satisfy customers. Though the industrial revolution brought manufacturing sector to the forefront, service sector contributed towards the rapid growth of business. The industrial revolution saw development of many services whose existence was important for economic development.

Example: Without development in transport and shipping services, goods would not have been able to move across the nations; without financial services and distribution of finance and wealth to entrepreneurs, business would not have got the desired feed for seeding and growth.

So a strong service industry emerged to meet the needs of manufacturing sector, to meet the demand patterns of intermediaries who took the output of manufacturing sector for wider distribution to consumers. Since then, service sector has come to stay as the biggest source of employment and value generation. Due to increase in competition, manufacturers started differentiating the product offer through quality of service delivered to customers. There is a close correlation between the level of economic development in an economy and the strength of its service sector. Service sector facilitates improved productivity and higher employment for the economy.

It is very difficult to find out the exact difference between products and services in today's context as what is being offered to consumers as a product is well supported by a bundle of

Notes

services, during and after the product is purchased and consumed. Above this level, there is a great service provider in the form of government and governmental departments affecting all aspects of our life. Private non-profit sectors like non-governmental agencies, religious and educational institutions, foundations, hospitals are also a part of the social sector. Business sectors include airlines, financial services, banks, insurance and merchant banking organizations; law firms, management and process consultants, entertainment companies, hotels and hospital industries constitute another sector of services.

Self Assessment

Fill in the blanks:

14. Deregulation, economic liberalization and rising expectations of consumers have made managers to apply managerial skills, practices and …… to satisfy customers.
15. Due to increase in competition, manufacturers started …… the product offer through quality of service delivered to customers.

Case Study

Apollo Hospitals

The Chief Executive of Apollo Hospitals is attempting to determine the capacity of their outpatients 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 Outpatient 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 outpatients 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.

Contd...

Notes

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.

Question

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

Source: Upendra Kachru, *Production and Operations Management – Text and Cases,* First Edition, Excel Books, New Delhi, 2007.

3.6 Summary

- Service is defined as any activity or benefit that one party can offer to another which is essentially intangible and does not result in ownership of anything.
- Pure services have distinct characteristics of intangibility, inseparability, perishability, variability and a lack of ownership.
- The Service Process Matrix is a categorization matrix of service industry firms based on the characteristics of the individual firm's service processes.
- Service quality is an important issue in marketing of services due to the fact that both production and consumption of services occur at the same time.
- The various service quality dimensions include reliability, responsiveness, assurance and empathy. The quality of a service will delight a customer when it exceeds the service expectations of the customers.
- There are five types of service quality gaps that a service marketer should try to bridge through an effective service-marketing program.
- An effective quality management program should try to develop strategies to fill the gaps and create customer delight.
- Service sector is one of the key contributing factors for growth of our economy and civilization.

3.7 Keywords

Consumer Services: These are aimed at individual consumers and are consumed for personal reasons.

Functional Quality: It relates to 'how' technical quality is being delivered to the consumer. This aspect cannot be as accurately measured as technical quality.

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Intangibility: A pure service is difficult to assess through any of the physical senses. It is a bundle of abstraction, which cannot be assessed before it is owned. This explains intangibility of services.

Perishability: Services cannot be separated from the source and hence they cannot be stored for future consumption.

Producer Services: These are meant for organizations that buy them to deliver either a product or service to the end customer.

Technical Quality: It relates to quantifiable aspects of service that is 'what' is being done. This aspect can be accurately measured.

Variability: Services cannot be standardized and hence they are variable in nature.

3.8 Review Questions

1. Define service concept and explain its relevance in a modern society.
2. Is it important to separate services and products in modern day marketing? Support your decision with suitable arguments.
3. What is a pure service? Explain the continuum of services.
4. Explain the characteristics of pure services.
5. Explain the role of intangibility in service marketing.
6. "Service Process Matrix can be helpful when investigating the strategic changes in service operations." Explain.
7. What are the key factors that can influence a customer's expectations, which may help customers in shaping their expectations of a service?
8. Why is quality an important factor in service marketing? How to measure dimensions of service quality?
9. Explain the role of following dimensions in measuring and managing service quality:
   (i) Reliability
   (ii) Responsiveness
   (iii) Empathy
   (iv) Assurance
10. What are service quality gaps? What strategies should you follow to fill up service quality gap? How many of these gaps are based on consumer perception and why?

Answers: Self Assessment

1.	empathy	2.	demand
3.	production	4.	intangible
5.	distribution	6.	strategic
7.	Labor intensity	8.	product-attributed
9.	positive image	10.	assurance

Notes

11. Consumer Oriented
12. Responsiveness
13. five
14. strategies
15. differentiating

3.9 Further Readings

Books

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

Tapan Panda, *Marketing Management – Text and Cases*, Excel Books, New Delhi.

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.

R C Manchanda, *Production and Operations Management*, Excel Books, New Delhi.

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

Online links

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

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

Notes

Unit 4: Quality Control

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Objectives

After studying this unit, you will be able to:

- Describe the meaning of quality;
- Discuss the statistical process control;
- Explain the conception of control charts.

Introduction

Quality has become a key economic factor in terms of staying competitive on a global basis. It has become necessary for promoting business growth. This is because quality leadership is linked to customer focus. If a company cares deeply for the needs of its customers it is bound to be successful. This is what the Toyota Motor Company has done so well year after year.

In order to be competitive, work needs to get done, customers need to get served, and day-to-day problems need to get addressed. These are some of the challenges of quality management. Actions of the leadership team set the pace and guide the direction of change. Jet Airways is a case and example of leading change in the airlines industry with the philosophy of providing growth and leadership in an industry through leadership in quality.

Notes

4.1 What is Quality?

"Quality in a product or service is not what the supplier puts in. It is what the customer gets out and is willing to pay for."

– Peter Drucker

Companies offering a powerful combination of low prices and high quality are capturing the hearts and wallets of consumers. Today as value driven companies are growing in number, they are moving from competing on price to providing quality, service and convenience. As value players gain share, at varying speeds, across economies, they change the nature of competition by transforming consumer attitudes about trade-offs between price and quality. Today, quality is considered an 'order qualifying' and not an 'order winning' attribute of the product or service.

How do you, as a consumer, evaluate quality? One approach which customers use to evaluate quality is to cite attributes of the product or its product delivery process.

Example: If someone were to ask you to judge the quality of a personal computer, you might reply by citing such things as: the way it looks, how long it took to set up, how long it takes to boot up, and whether or not it has Intel Inside.

If the product is a service, such as a meal, the determinants of quality might include: the meal itself, its presentation, the manner in which it was delivered, and quite possibly the behaviour of the people at the next table.

In effect, you are citing attributes of quality, i.e., the traits associated with quality that can be identified and, more importantly, measured. Attributes, however, are not the same as quality. Identifying every attribute of quality for a product would not describe that product's quality level. Some attributes used to help define quality are:

1. ***Freshness:*** Some products are perishable, i.e., the quality declines over time. Vegetables fall "into this category. Fashion items also are subject to obsolescence. At the other extreme, "the value associated with some products increases with age, as is the case with antiques and red wine.
2. ***Reliability:*** The quality associated with a product often increases with the dependability of the product customer experience. Patients expect the hospitals to have competent staff. Customers expect telephones to work. Ni-Cd Batteries manufactured by ECIL should be as reliable as other internationally manufactured batteries.
3. ***Durability:*** The quality attribute that implies product performance under adverse conditions. Eveready's Red commercials are designed to convey the durability of its batteries.
4. ***Safety:*** This is an attribute of quality that measures the likelihood of harm from goods or service. What is safe can be a controversial issue. For instance, is a gun with a safety clip safe? Is the packaging of a product tamper proof?
5. ***Environmental Friendly:*** As is the case with safety, this quality attribute has both societal aspects and is individual specific. The requirements for being considered an environmental friendly product are becoming more stringent. For example, firms must now also focus on how a product is disposed off after its useful life.
6. ***Serviceability:*** This attribute relates to the ease and cost associated with servicing a product after the sale has been made. Products are now being increasingly designed so that they do not need service, such as car batteries. But many others do require service and this capability

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must be both designed into the product and the post-sale service system. This is especially important for consumer durables. ECIL, perhaps, has not been able to convey that it has an adequate service organization for the televisions it manufactures.

7. ***Aesthetics:*** A product's appearance, feel, sound, taste, or smell reflects its aesthetics. Aesthetics are hard to define; it is customer specific and sometimes situation specific. What is aesthetically pleasing to one individual may be considered ugly by another.

8. ***Attribute Consistency:*** The attributes associated with a product should be internally consistent. It would make little sense to build a Maruti 800 with airfoils, or a biodegradable cigarette filter. Products with inconsistent combinations of features aren't likely to match the needs of their buyers.

To a certain degree, the functionality and the quality overlap. Products with excellent designs will excel in attributes that matter. These in turn increase the functionality of the product.

Definition of Quality

Concepts of what constitutes quality have changed over the last decade. Traditional definitions focused on conformance to standards. Such definitions were based on the customer's perception of quality. The new definition of quality that has emerged focuses on achieving value entitlement.

Quality is a state in which value entitlement is realized for the customer and provider in every aspect of the business relationship.

Did u know? **What is Value?**

'Value' represents economic worth, practical utility and availability for both the customer and the company that creates the product or service.

This definition accepts the fact that the quality of products or services rarely consist of a single element. 'Value entitlement' means:

1. For the customer – a rightful level of expectation to buy high-quality products at the lowest possible cost.

2. For the provider – a rightful level of expectation to produce quality products at the highest possible profits.

Self Assessment

Fill in the blanks:

1. A product's appearance, feel, sound, taste, or smell reflects its …… .

2. …… is an attribute of quality that measures the likelihood of harm from goods or service.

3. Quality is a state in which …… entitlement is realized for the customer and provider in every aspect of the business relationship.

4. …… attribute relates to the ease and cost associated with servicing a product after the sale has been made.

5. The quality attribute that implies product performance under adverse conditions is …… .

Notes

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 Coonoor 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 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 CTTA 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 heartbreaking 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 at least ₹ 15 per kg and plainer ones by ₹ 4-6," he said.

Source: Article at financialexpress.com

4.2 Statistical Process Control

The concept of process variability forms the heart of statistical process control. This process variation can be partitioned into two components. Natural process variation or system variation is the naturally occurring fluctuation or variation inherent in all processes. Special cause variation is typically caused by some problem or extraordinary occurrence in the system.

World-class companies combine early inspection with Statistical Process Control (SPC) to monitor quality and detect and correct abnormalities. Using statistical process control, the process is monitored through sampling. Important decisions in implementing such programs include how to measure quality characteristics, what size sample to collect, and at which stage in the process to conduct inspections.

Notes

SPC uses control charts to determine if a process is within controlled parameters.

1. If it is determined that a process is 'out of control',
2. SPC provides the opportunity to investigate and determine the cause of this condition.
3. When the root cause of the problem is determined, a strategy can be identified to correct it.
4. Adjustments can be made to the process so that the process is unable to produce defective parts.
5. The investigation and subsequent correction strategy is frequently a team process and one or more of the TQM process improvement tools are used to identify the root cause.

4.2.1 Control Charts

When the quality of a product depends on some measurable physical quantity, e.g., weight, height, length, diameter, etc., control charts are used to ensure that these quantities are within limits permitted by the process. Control charts are time-sequenced charts showing plotted values of a statistic including a centerline average and one or more control limits.

Central Limit Theorem of Statistics

1. Data on the critical characteristic in a large lot of an item that is produced by an operation will often display a pattern similar to a normal distribution. The theoretical basis of control charts is the Central Limit Theorem of statistics.
2. Control charts use this theorem to predict the performance of a process.
3. The theorem specifies that if we compute averages of many random samples, the characteristics will be distributed approximately normally irrespective of the distribution of the specific characteristic, if the subgroups are ordered in time.

This means that we can use a control chart based upon the properties of the normal distribution to determine if the operation was 'in control' during its performance.

The control chart will, therefore, also indicate the likelihood if the process were going out of control. It also imputes that the lot of characteristics about the mean will be similar to the measured ranges of the samples. The standard deviation of the ranges can be calculated by formula derived from the normal distribution.

There can be two types of control charts representing the two types of sampling:

1. Control charts for variables, and
2. Control charts for attributes.

1. ***Control charts for variable:*** In the case of variables, control of the process average or mean quality level is usually determined with the control chart for means (μ), or the X bar chart. The control of the variability of the process is determined by using the control chart for range, or the R chart. The X bar chart is developed from the average of each subgroup data, i.e., the data in each R chart is taken as a single reading, and from a number of these data points, the X bar chart is constructed.
2. ***Control charts for attributes:*** Similarly, control charts for sampling by attributes are called 'p' charts. 'P' charts measure the variability in a process. c-chart is another device for controlling attributes. It is used where the total number of defects (of all kinds) in the product must be kept under control. The c-chart is useful where the opportunity for defects is large while the actual occurrence is small.

   Control Charts, rather than merely identifying defectives after they are produced, as in acceptance sampling, help to prevent the production of defectives.

Notes

The common approach to on-line quality control is straightforward: We simply take out samples of a definite size from the ongoing production process. We afterward produce line charts of the variability in those samples and think about their closeness to target specifications. If a trend comes into view in those lines, or if samples fall outside pre-specified limits, we state the process to be out of control and take action to locate the cause of the problem. These types of charts are at times also referred to as Shewhart control charts named after W. A. Shewhart, who is usually credited as being the first to initiate these methods.

Short Run Control Charts

The short run control chart, or else control chart for short production runs, plots interpretation of variables or attributes for several parts on the same chart. Short run control charts were developed to deal with the requirement that several dozen measurements of a process have to be collected before control limits are calculated. Meeting this requirement is habitually difficult for operations that produce a limited number of an exacting part during a production run.

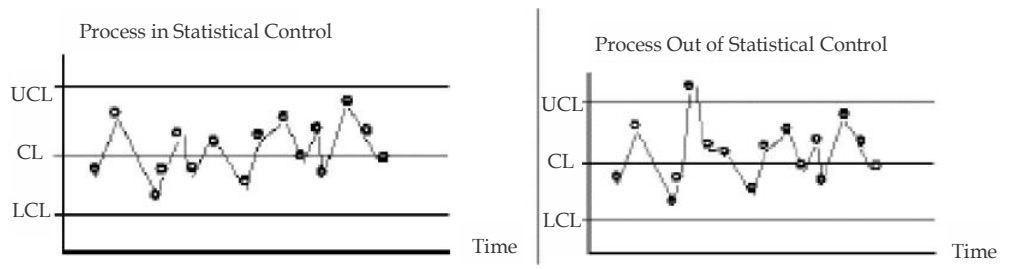
Example: A paper mill may produce only three or four (huge) rolls of a particular kind of paper (i.e., *part*) and then shift production to another kind of paper. But if variables, such as paper thickness, or attributes, such as blemishes, are monitored for several dozen rolls of paper of, say, a dozen different kinds, control limits for thickness and blemishes could be calculated for the *transformed* (within the short production run) variable values of interest.

4.2.2 Control Limits

We are aware from our basic statistics course that plus and minus three standard deviations from the mean of normal destruction will include 99.73 per cent of all data in the distribution. When the mean absolute deviation of a data set is less than three standard deviations, it is considered to be within acceptable limits or error. Using the same rationale, the Upper Control Limit (UCL) is calculated as 3s and set on the chart as shown in Figure below. The Lower Control Limit (LCL) is established in the same manner. These are the limits in which the measured parameters are expected to fall into.

Although, industry practice is to use three standard deviations, some applications may merit the use of wider or narrower control limits. However, the measure of limits is always based on standard deviations.

Figure 4.1: Control Charts



We can see that the process on the left in Figure 4.1 is in apparent statistical control. All the points lay within the Upper Control Limits (UCL) and the Lower Control Limits (LCL). The variation seen in the points in the figure on the left is due to common cause variation, which is considered a part of the process. Common cause variation is variation in the process that cannot be attributed to any defect.

Notes

However, the process shown in the right-hand side figure is out of statistical control. Notice that a single point is outside the control limits (above them). This means that a source of special cause variation is present. A special cause variation is a variation that can be attributed to defects in the process, i.e., the process is not in control as it should be. Having a point outside the control limits is the most easily detectable out-of-control condition. Though the likelihood of this happening by chance is only about 1 in 1,000, this source of special variation has to be isolated and dealt with.

Figure 4.2: A Typical Cycle in SPC

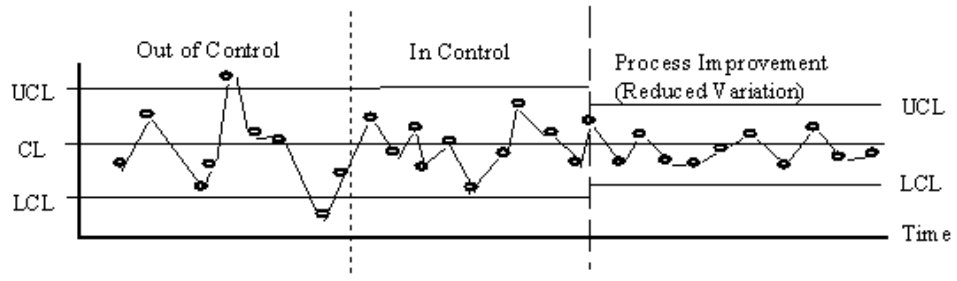


Figure 4.2 illustrates the typical cycle in SPC. In the first segment, the process is highly variable and out of statistical control. As special causes of variation are found and eliminated, the process comes into statistical control in the second segment. Finally, through process improvement, variation is reduced. The narrowing of the control limits generally is an indication of process improvement. The chart in the figure is educative in that it shows that by eliminating special cause variation the process can be brought in control; and by process improvement we can reduce the process variation and move the control limits in towards the centerline of the process.

By following this system on an ongoing basis, we help to prevent the production of defectives. The first step for the analysis of a control chart is to determine, what patterns one should look out for? What are the patterns that indicate that a process is going out of control?

4.2.3 Analysis of Patterns on Control Charts

A control chart may indicate an out-of-control condition either when one or more points fall beyond the control limits. This pattern may indicate an out-of-control condition which is due to a special cause of variance from a material, equipment, method, or measurement system change.

Caution It should be remembered that Control chart may also indicate wrong measurement of a part or parts, miscalculated or wrongly plotted data points, and/or miscalculated or wrongly plotted control limits.

Other patterns that should create concern are when the plotted points exhibit some non-random pattern of behaviour. These situations are described below and need to be looked into:

1. A run of eight points on one side of the center line. This pattern indicates a shift in the process output from changes in the equipment, methods, or materials or a shift in the measurement system.
2. An unusual or non-random pattern in the data; e.g., a trend of seven points in a row upward or downward. This may show a gradual deterioration or wear in equipment; improvement or deterioration in technique.

Notes

3. Cycling of data can indicate that temperature or other recurring changes in the environment; differences between operators or operator techniques; rotation of machines; or differences in measuring or testing devices being used.

4. Several points near a warning or control limit.

In addition, care needs to be exercised when two of three consecutive points are outside the 2-sigma warning limits but still inside the control limits. This may be the result of a large shift in the process in the equipment, methods, materials, or operator or a shift in the measurement system. Even when four of five consecutive points are beyond the 1-sigma limits, it should be a matter of concern. Vigilance ensures that we prevent defectives and not just identify defectives.

4.2.4 Control Charts for Variables

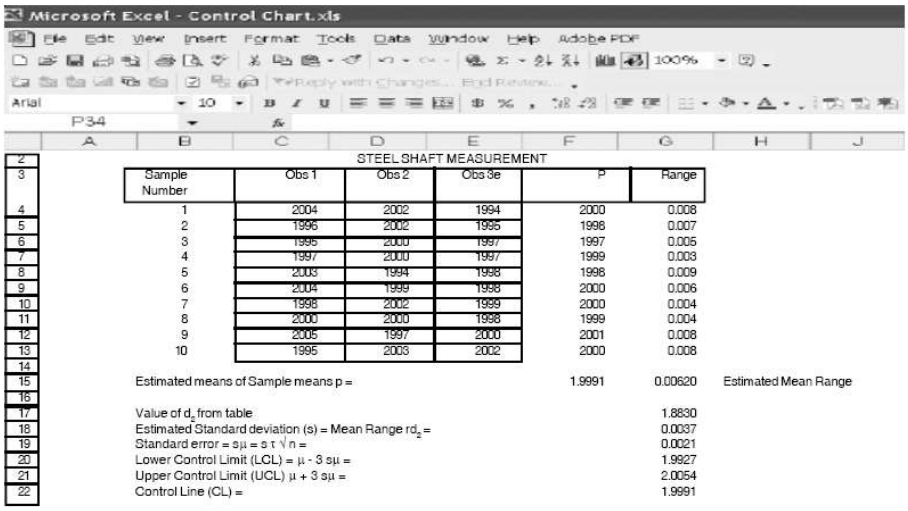
Many quality characteristics can be expressed in terms of a numerical measurement. A single measurable quality characteristic, such as a dimension, weight, or volume, is called a variable. Control charts for variables are the most extensively used control charts in industry. They usually lead to more efficient control procedures and provide more information about process performance than do attributes control charts.

Constructing charts for means (μ) and X bar chart using MS Excel: The R chart is developed from the ranges of each subgroup data, which is calculated by subtracting the maximum and the minimum value in each subgroup. An example showing the development of the charts is provided.

Let us take an example showing the procedure for making X bar and R Control Charts. We have discussed the specifications of the steel shaft in an earlier section. Let us consider the measurements taken on the diameter of the shaft. The aim is to achieve statistical control of the diameter using X bar and R charts. Measurements of the diameter of ten samples, each of three units, have been taken when the process is assumed to be in control.

The data was entered into an Excel worksheet as shown in Table below. The mean in each sample was calculated by selecting the S symbol on the Excel Toolbar and selecting 'average' on the drop down menu. The averages of each row represent the 'μ' value for each set of samples. The data selected automatically by the program needs to be checked and corrected to include only the data that represented the observations.

Table 4.1: Data for Measurement on Steel Shaft



Microsoft Excel - Control Chart.xls

STEEL SHAFT MEASUREMENT

Sample Number	Obs 1	Obs 2	Obs 3e	P	Range
1	2004	2002	1994	2000	0.008
2	1996	2002	1995	1998	0.007
3	1995	2000	1997	1997	0.005
4	1997	2000	1997	1999	0.003
5	2003	1994	1998	1998	0.009
6	2004	1999	1998	2000	0.006
7	1998	2002	1999	2000	0.004
8	2000	2000	1998	1999	0.004
9	2005	1997	2000	2001	0.008
10	1995	2003	2002	2000	0.008

Estimated means of Sample means p =	1.9991	0.00620 Estimated Mean Range
Value of d_2 from table		1.8830
Estimated Standard deviation (s) = Mean Range rd_2 =		0.0037
Standard error = sμ = s τ √n =		0.0021
Lower Control Limit (LCL) = μ - 3 sμ =		1.9927
Upper Control Limit (UCL) μ + 3 sμ =		2.0054
Control Line (CL) =		1.9991

Notes

The range was calculated by visually examining the observation data in each row and subtracting the largest number from the smallest number. The range is a measure of dispersion, i.e. it is the difference between the maximum and minimum values in a sample.

The mean of the means was found by selecting the S symbol and averaging the values of 'μ'. This time we are averaging a column and must ensure that the correct column is selected. The mean of the ranges are also calculated in a similar manner by selecting the S symbol and averaging the values of 'R'. The mean values are shown in row 15 in the table.

Standard tables are available that give the number of defective pieces acceptable in each lot based on the size of the sample. Using such a table, with n = 3, we get; d2 = 1.693. The standard deviation of the sample can be calculated by dividing the value of the mean of the range (μ) by the value d2.

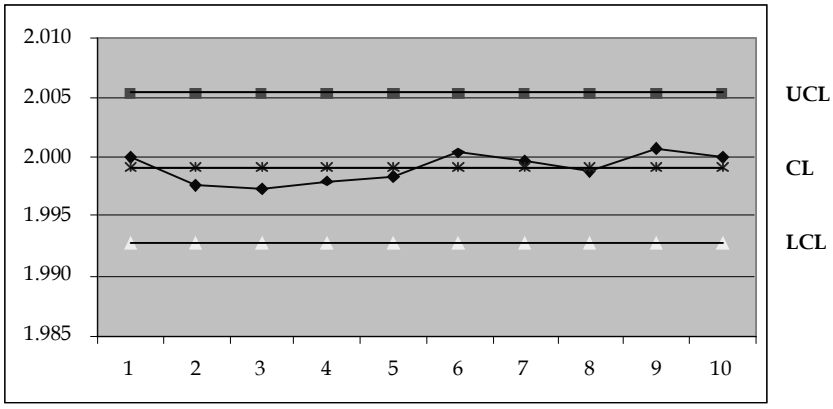
The standard error of the sample is obtained using the formula given below and is shown in row 18 of the figure.

$$s\mu = s / v\ n$$

Though the Upper Control Limit (UCL) and the Lower Control Limit (LCL), by convention and due to standard statistical practice, it is normally fixed at 3 times the standard deviation. Based on this rationale, the UCL and LCL have been shown in rows 20 and 21 in the figure.

The data in the table and the additional calculations can now be converted into a graphical presentation using the Chart Wizard in Excel. Use the 'line type' chart type and provide values for the 4 series, i.e., means of samples, UCL, CL and LCL. The y-axis should represent the variable measurement and the x-axis represents the sequence of samples. A control chart for the example we have been following is shown as Figure 4.3.

Figure 4.3: R Chart using MS Excel



The R chart indicates that the process is in control. All the points fall between the UCL and LCL. As a matter of fact, the process seems to be in excellent control, all the points are very close to the CL. However, this needs to be verified. When dealing with a quality characteristic that is a variable, it is a standard practice to control both the mean value of the quality characteristic and its variability. This is done by using the R chart.

The R Chart: The basic data for the R chart was shown in Table 4.2 and its calculation explained. From standard tables, with n = 3, we get the value of d3; which relates to the variability of the sample. In this case, d3 = 1.693. This value is used to obtain the standard deviation of the range.

Notes

The mean for the ranges gives the center line for the R chart. Using standard statistical practice, the Upper Control Limit (UCL) and the Lower Control Limit (LCL), are calculated at 3 times the standard deviation. Based on this rationale, the UCL and LCL have been shown in rows 19 and 20 in Table 4.2.

Table 4.2: The R Chart Table

Microsoft Excel - Control Chart.xls

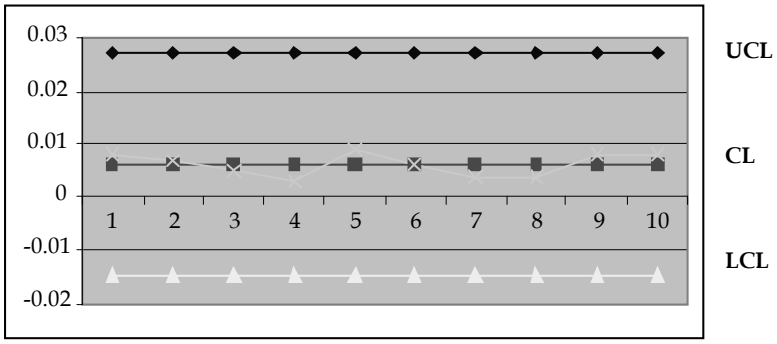
STEEL SHAFT MEASUREMENT (R Chart)

Sample Number	Obs 1	Obs 2	Obs 3e	P	Range
1	2004	2002	1994	2000	0.008
2	1996	2002	1995	1998	0.007
3	1995	2000	1997	1997	0.005
4	1997	2000	1997	1999	0.003
5	2003	1994	1998	1998	0.009
6	2004	1999	1998	2000	0.006
7	1998	2002	1999	2000	0.004
8	2000	2000	1998	1999	0.004
9	2005	1997	2000	2001	0.008
10	1995	2003	2002	2000	0.008

Estimated means of Sample means p =	1.9991	0.00620	Estimated Mean Range
Value of d_2 from table		1.889	
Estimated Standard deviation (s) = Mean Range rd_2 =		0.006882	
Lower Control Limit (LCL) = μ - 3 sμ =		0.0147	
Upper Control Limit (UCL) μ + 3 sμ =		0.0271	
Control Line (CL) =		0.0082	

The data can now be converted into a graphical presentation using the Chart Wizard in Excel. As previously in the case of the μ chart, the 'line type' chart type is used and values for the 4 series, i.e., means of ranges, UCL, CL and LCL incorporated. The y-axis should represent the variable measurement and the x-axis represents the sequence of samples. The control chart that results is shown as Figure 4.4.

Figure 4.4: R Chart for Steel Shaft



It can be seen that all the points are within the UCL and the LCL. Since the process variability is in control, the process is in control. These charts are stable and can now be used as benchmarks.

This means that, given the stated levels, these control limits can be adopted for use in online statistical process control. The X bar chart can now constructed. However, control charts require to be updated continuously. Old data should be discarded and replaced by new data. This is necessary, in spite of the fact that the data may show that both the R and the X bar chart exhibit control.

Notes

Such problems can also be worked out manually as the solved example below shows:

Example: Construct a control chart for mean and the range for the following data on the basis of the data provided for fuses, samples of 5 being taken every hour (each set of 5 has been arranged in ascending order of magnitude).

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12
42	42	10	36	42	51	60	18	15	69	64	61
65	45	24	54	51	74	60	20	30	109	90	78
75	68	80	89	57	75	72	27	39	113	93	94
78	72	81	77	59	78	95	42	62	118	109	109
87	90	81	84	78	132	138	60	84	153	112	136

Comment on whether the production seems to be under control.

Answer

From the data provided, we can calculate the sample mean and the sample range for X-Chart and the R-Chart. These calculations are given in a tabular form below:

Sample No.	Sample observations					Total ΣX	Sample Mean X	Sample Range
1.	42	65	75	78	87	347	69.4	45
2.	42	45	68	72	90	317	63.4	48
3.	19	24	80	81	81	285	57.0	62
4.	36	54	69	77	84	320	64.0	48
5.	42	51	57	59	78	287	57.4	36
6.	51	74	75	78	132	410	82.0	81
7.	60	60	72	98	138	425	85.0	78
8.	18	20	27	42	60	167	33.4	42
9.	15	30	30	62	84	230	46.0	69
10.	69	109	113	118	153	562	112.4	84
11.	64	90	93	109	112	468	93.6	48
12.	61	78	94	109	136	478	95.6	75
Total							Σξ = 859.2	ΣR =716

(i) The mean of sample mean.

The sum of 12 sample means (Σ) is:

$\overline{X} = \Sigma\ \overline{X}\ /\ 12 = 859.2 / 12 = 71.6$

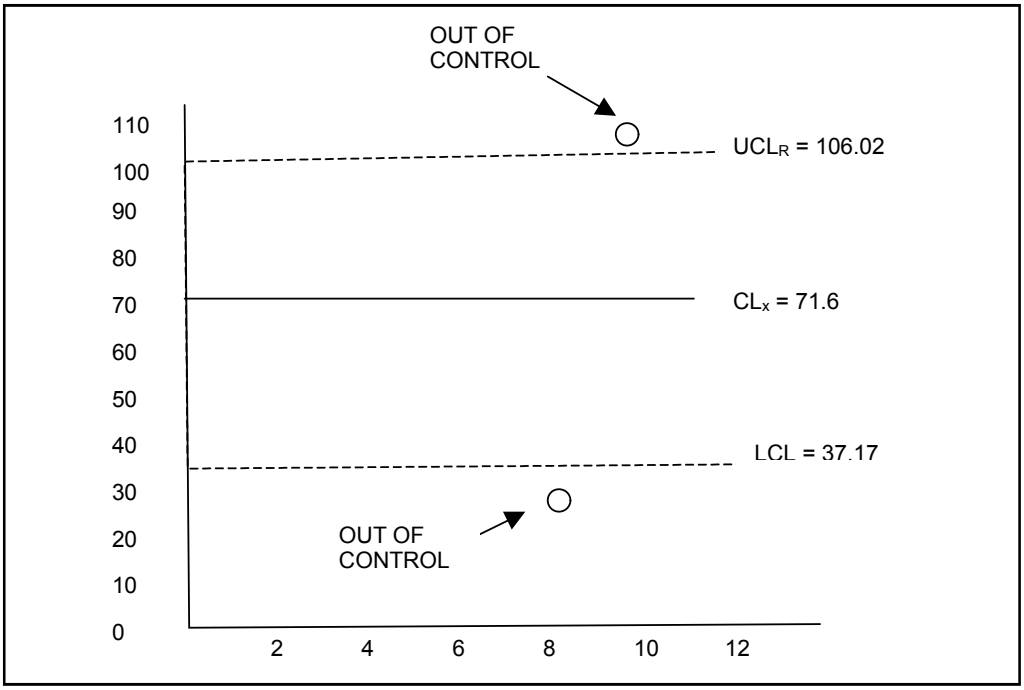
(ii) The mean, of the sample ranges, denoted by R is calculated as follows

$\overline{R} = 716/12 = 59.66$

Notes

(iii) The value of A_2. From tables the values are given.

For n = 5, A_2 = 0.577, D_3 = 0 and D_4 = 2115.



The upper control limit (UCL) and the lower control limit (LCL) are calculated as follows:

UCLX = + A_2 = 71.6 + 0.577 (59.66) = 106.024

LCLX = – A_2 = 71.6 – 0.577 (59.66) = 37.176.

The control chart for this example is shown above.

Since the sample mean points corresponding to sample numbers 8 and 10 lie outside the control limits, the X-chart indicates lack of control in process average. This suggests the presence of some assignable causes of variations which must be detected and corrected.

Eliminating these points from X -chart only.

Revised = [859.2 – (33.4 + 112.4)]/ (12–2) = 71.34

New UCL = 71.34 + A_2 = 71.34 + 34.6 = 105.94

New LCL = 71.34 + R_2 = 71.34 – 34.6 = 36.74.

Control limits for R-chart. The 3-s control limits are given by:

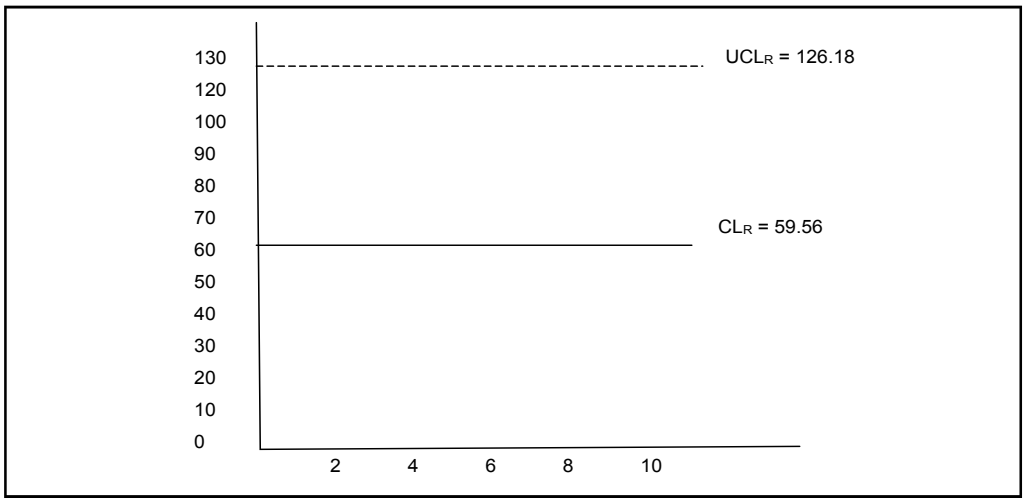
UCLR = D4R = 2.115 × 59.66 = 126.1809

LCLR = D3R = 0

CLR = R = 59.66

Notes

The control chart for R is shown below:



The chart shows that the process variability is under control since all the sample (ranges) plotted on the chart are within the control limits.

4.2.5 Control Charts for Attributes

Taking the example of the steel shaft, a way to control the process is to use go-no go-gauges to check the diameter. These gauges will determine whether or not the samples are within tolerance levels. The units within the samples that do not conform are defectives. These are counted and used as the basis for developing the control chart.

The 'p' chart is set up in essentially the same manner as the 'μ' or X bar chart in the control of variables. It is used to control the fraction defective in the output of an operation while the operation is being performed. The mean percentage defective (x) is taken as an approximation to the true percentage defective of the operation. The standard deviation of the distribution of the sample is determined using the formula:

sp = v (p*q / n)

where: 'p' is the number of defective units

'q' is the number of error free units (i.e. q = 1 - p), and

sp is the standard deviation.

The same general considerations employed in constructing X bar and R control charts for variables are applicable in control charts for attributes. The control limits are calculated using 3 times the standard deviation. The UCL is normally taken as p + 3sp and the LCL is taken as p - 3sp. If points are found beyond the limits, the assignable causes, if any, are eliminated, the control limits recalculated and the chart is used thereafter for the duration of the lot run. Sample sizes and intervals between samples should be constant or the same control limits will not apply.

The other chart used for control of attributes is called the c-chart. This finds application when the criteria for deciding on quality are the number of defects each unit of the product has.

Example: In carpet manufacturing inconsistencies in weave or inconsistencies in design are often the basis for accepting or rejecting carpets. The number of such inconsistencies is used to determine the quality of the carpet. This can be done using the c-chart.

Notes

In this case, it is assumed that the pattern of defects per unit follows the Poisson distribution. The mathematics of the Poisson distribution is used to establish the mean and control limits for the c - chart.

Task TELCO manufactures valves for its engines on the Tata truck. 8 valves are used on each truck. These valves are manufactured on a high-speed automated machine. The machine is set up to produce a large run of valves of 10,000 numbers in each set up. The specified dimension of the valve diameter is 2 + .001 - .002 inches.

To set up the machine and to create a control chart to be used throughout the run, 15 samples were taken with four valves in each sample. The complete list of samples and their measured values are as follows:

Sample Number	Readings (in inches)			
	Valve 1	Valve 2	Valve 3	Valve 4
1	2.0010	2.0006	2.0009	2.0011
2	1.9993	1.9966	2.0095	1.9994
3	1.9900	1.9880	1.9815	1.9808
4	1.9701	2.0010	2.1009	1.9980
5	1.9903	1.9809	1.9775	1.9930
6	1.9940	1.9701	1.9940	1.9805
7	1.9890	1.9920	1.9820	2.0020
8	1.9801	1.9860	1.9960	1.9960
9	2.1006	1.9890	2.1005	2.1007
10	1.9920	2.1007	2.1006	1.9790
11	1.9960	2.1006	1.9970	1.9890
12	2.0019	1.9960	1.9910	2.0011
13	1.9810	1.9910	1.9890	2.0003
14	1.9990	1.9930	1.9880	1.9840
15	2.0101	2.0002	2.0005	2.0009

Develop an X chart and an R chart and plot the values.

From the charts, what comments can you make about the process?

Self Assessment

Fill in the blanks:

6. The R chart indicates that the process is in …… .
7. The short run control chart plots interpretation of variables or attributes for several parts on the …… chart.
8. SPC uses …… to determine if a process is within controlled parameters.
9. The …… is a measure of dispersion, i.e. it is the difference between the maximum and minimum values in a sample.
10. The 'p' chart is used to control the …… defective in the output of an operation while the operation is being performed.
11. The c-chart is useful where the opportunity for defects is large while the …… is small.

Notes

4.3 Analytical Tools

Quality has became a very serious issue in mass production systems because no longer are the parts hand-built and individually fitted to the product. Mass-produced parts have to function properly in every product built. Management wants as little total variation in a process as possible—both common cause and special cause variation.

Reduced Variation

1. Reduced variation makes the process more predictable with process output closer to the desired or nominal value.
2. The desire for absolutely minimal variation mandates working toward the goal of reduced process variation.

Product or Service Inspections

1. Product or service inspections generate data on variations of characteristics, processes and products.
2. Several ways are used to generate data by the measurement of specific characteristics of the product or process.

Once the specific data has been collected, valuable techniques, such as check lists, bar charts, scatter diagrams, Pareto analysis, fish-bone diagrams, etc., can be used to analyze and find ways to reduce process variation, communicate quality issues, etc. Each of the tools may be used independently, but their power grows if they are combined or used together. In solving a quality problem, managers often shift data to clarify the issues involved and deducing the causes.

The analytical tools discussed below are used in traditional quality improvement programs. They are also used in Six Sigma, though their application and integration in a corporate wide management system is in some ways unique.

4.3.1 Checklists and Tally Charts

Two common methods to capture the data are (a) checklists, and (b) tally charts.

Checklist

A checklist is a form used to record the frequency of occurrence of certain product or service characteristic related to quality, and is often the first step in the analysis of quality problems.

Figure 4.5: Checklist

Checkpoint	Passed	Failed
Glass is tempered	✓	
Feet are in wood	✓	
Assembly test	✓	
Flat packing		✓

Tally Chart

A tally chart is, similarly, a quick way of counting how many occurrences there are in each category. These are counted in order and a mark put in the correct place. When you get to 5, put a mark across, i.e., the fifth mark is the crossing line.

Notes

Example: The pupils in a class were asked how they got to school. The frequency is how often a particular response occurred. We can see that the frequency of 'walk' is 9, so there must have been 9 pupils who said that they walked to school. Information can be counted or grouped into convenient categories or a range, e.g., height of plants in cm. 1 to 5 cm. 6 to 10 cm., etc. The characteristics may be measurable on a continuous scale e.g., diameter, time, or length; or on a yes-or-no basis (go-no-go); e.g. diameter, time, or length.

Table 4.3: Tally Chart

Method of Travel	Tally	Frequency
Walk	卌 IIII	9
Bike	III	3
Car	卌 I	6
Bus	卌 卌 II	12
	Total	30

4.3.2 Histograms and Graphs

Information from the checklist of tally chart is used to construct histograms or bar charts. These are basic forms that help standardize data collection.

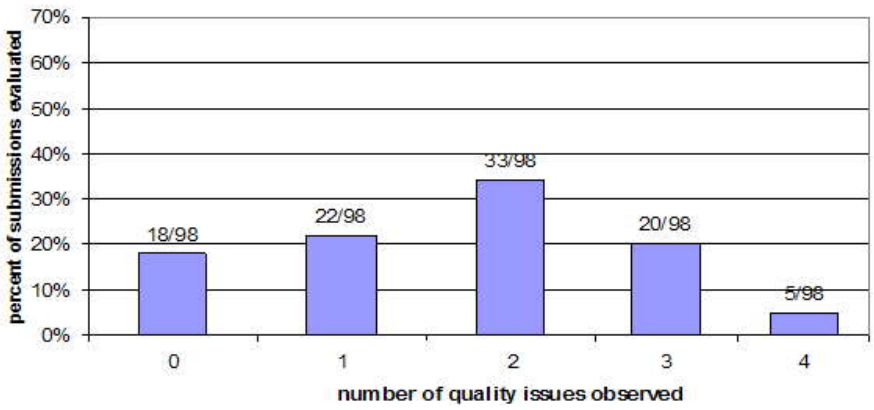
A histogram summarizes data measured on a continuous scale, showing the frequency distribution of some quality characteristic (in statistical terms, the central tendency and dispersion of the data). Often the mean of the data is indicated on the histogram.

Graphs are perhaps the most widely used but least talked about tools in business. Graphs are convenient ways to clearly show your data. They represent data in a variety of formats. The selection of a graph should be on the basis of the kind and purpose of data that needs to be presented. There are three basic graph forms and their variations: the bar graph, the line graph, and the pie graph.

Bar Graph

- A bar graph is used to show relationships between groups.
- A series of bars representing the frequency of occurrence of data characteristics measured on a yes-or-no basis.

Figure 4.6: A Bar Graph



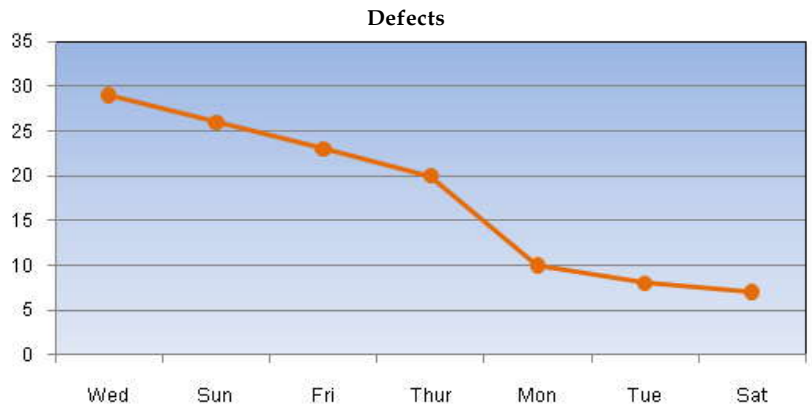
Notes

- The bar height indicates the number of times a particular quality characteristic was observed.
- The two items being compared do not need to affect each other. It's a fast way to show big differences.

Line Graphs

1. Line graphs represent data sequentially with data points connected by line segments to highlight trends in the data.
2. Line graphs are used to show continuing data; how one thing is affected by another e.g., in control charts and forecasting.

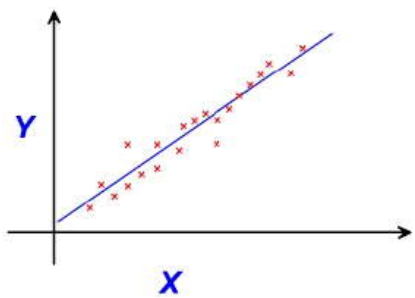
Figure 4.7: A Line Graph



A variation of a line graph is a scatter diagram.

- It is a plot of two variables plotted along two axes used to determine whether the variables are related.
- Each point on the scatter diagram represents one data observation. For example, there may be a suspicion that defects of the shaft that we discussed earlier are a function of the limitations of the casting process, i.e., the casting process for that particular diameter produces too many defects.
- A scatter diagram could be constructed by plotting the number of defective castings found for each diameter of casting produced.
- After the diagram is completed, any relationship between and number of defects for shafts of different diameters and the casting process can become apparent.

Figure 4.8: A Scatter Diagram



Notes

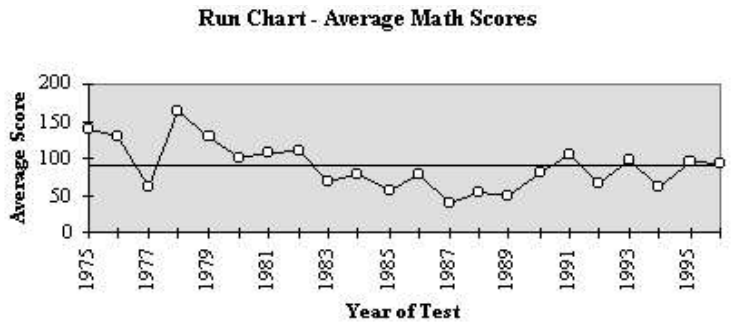
Did u know? **What is a run chart?**

A run chart is a line graph that shows data points plotted in the order in which they occur.

Usage of run chart

- They are used to show trends and shifts in a process over time, variation over time, or to identify decline or improvement in a process over time.
- They can be used to examine both variables and attribute data.
- In case of problem, this information is helpful to understand the magnitude of a problem.

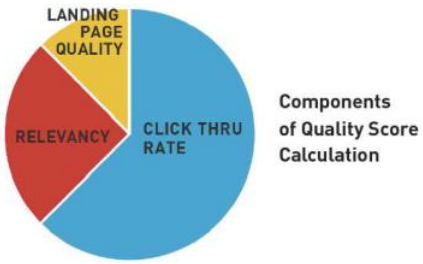
Figure 4.9: A Typical Run Chart



Pie Charts

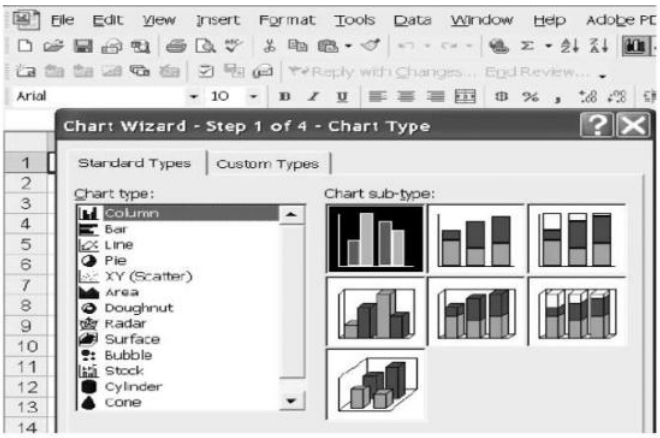
- Pie charts represent quality factors as slices of a pie: the size of each slice is in proportion to the number of occurrences of the factor.
- A pie chart is used to show how a part of something relates to the whole.
- These charts are useful for showing data from a group of factors that can be represented as percentages totaling 100 per cent.

Figure 4.10: A Pie Chart



Notes

Figure 4.11: Using MS Excel to Create Graphs



The easiest way to create a graph is to enter your data into a spreadsheet program; e.g., Microsoft Excel, etc. These programs will generate graphs from the data you enter. MS Excel has the graph toolbar on the main toolbar, as can be seen in Figure 4.11. The figure shows the types of graphs that can be done Excel programs.

4.3.3 Pareto Charts

A Pareto chart is used to graphically summarize and display the relative importance of the differences between groups of data. The Pareto diagram is named after Vilfredo Pareto, a 19th-century Italian economist who postulated that a large share of wealth is owned by a small percentage of the population. This is often referred to as the 80-20 rule; that is, 80 per cent of problems are caused by 20 per cent of the potential sources.

A Pareto diagram puts data in a hierarchical order, which allows the most significant problems to be corrected first. The Pareto analysis technique is used primarily to identify and evaluate non-conformities, although it can summarize all types of data. It is also used to analyzing the before and after impact of changes made in a process.

Notes **How to Construct Pareto Chart**

- A Pareto chart can be constructed by segmenting the range of the data into groups (also called segments, bins or categories).
- The left-side vertical axis of the Pareto chart is labeled 'frequency' (the number of counts for each category), the right-side vertical axis of the Pareto chart is the cumulative percentage, and the horizontal axis of the Pareto chart is labeled with the group names of the response variables.
- The numbers of data points that reside within each group are determined.
- Select a standard unit of measurement and the time period to be studied.
- Collect and summarize the data to construct a Pareto chart. Unlike the bar chart, the Pareto chart is ordered in descending frequency magnitude. The groups are defined by the user.

Contd...

Notes

Pareto Diagram Analysis

- Pareto analysis provides the mechanism to control and direct effort to establish top priorities and to identify both profitable and unprofitable targets.
- Pareto analysis is useful in a number of applications, e.g., prioritize problems, goals, and objectives; identify root causes; select key customer relations and service programs; select key employee relations improvement programs; select and define key performance improvement programs; allocate physical, financial and human resources, etc.
- In addition, as mentioned earlier, it is used to identify the 'critical success factors'.

Figure 4.12: A Pareto Diagram

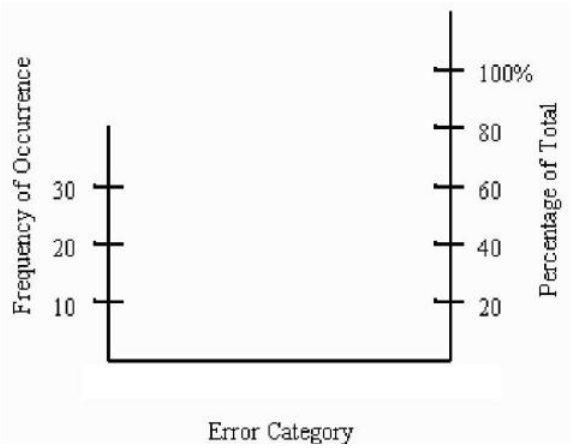


Table 4.4 shows the pattern of errors that contribute to the cost of photocopying. We see that operator errors contribute to photocopying quality costs as much as all other sources combined. We need to focus on operator error to bring down costs. If we further break down this category into items such as poor job instructions, inadequate attention to machine, and so forth, we would expect to find a few vital sources that primarily contribute to costs.

Table 4.4: Quality Costs in Photocopying

Class of Loss	Annual Quality Loss (in ₹)	Frequency of Loss (in %)	Cumulative Frequency of loss (in %)
Operator error	600	50.0	50.0
Dirty, spotted drum or glass	300	25.0	75.0
Low ink level	150	12.5	87.5
Paper misfeed	75	6.25	93.75
All other sources	75	6.25	100.00

Pareto analysis is also applicable in the presentation of PIs through selection of representative process characteristics that truly determine or directly or indirectly influence or confirm the desired quality or performance result or outcome.

Notes

Self Assessment

Fill in the blanks:

12. Reduced variation makes the process more predictable with process output closer to the desired or …… value.
13. A checklist is a …… used to record the frequency of occurrence of certain product or service characteristic related to quality.
14. Line graphs represent data sequentially with …… connected by line segments to highlight trends in the data.
15. A Pareto chart is used to graphically summarize and display the …… importance of the differences between groups of data.

4.4 Summary

- Quality is a state in which value entitlement is realized for the customer and provider in every aspect of the business relationship.
- World-class companies combine early inspection with Statistical Process Control (SPC) to monitor quality and detect and correct abnormalities.
- Statistical Process Control uses control charts to determine if a process is within controlled parameters.
- There can be two types of control charts representing the two types of sampling which are Control charts for variables, and Control charts for attributes.
- The R chart is developed from the ranges of each subgroup data, which is calculated by subtracting the maximum and the minimum value in each subgroup.
- In the case of variables, control of the process average or mean quality level is usually determined with the control chart for means (μ), or the X bar chart.
- The c-chart is useful where the opportunity for defects is large while the actual occurrence is small.
- The 'p' chart is used to control the fraction defective in the output of an operation while the operation is being performed.
- Two common methods to capture the data are (a) checklists, and (b) tally charts.
- A Pareto chart is used to graphically summarize and display the relative importance of the differences between groups of data.

4.5 Keywords

Hard Attributes: These are those attributes that must be met by the delivered product or service if it is to be considered satisfactory.

Operating Characteristic Curves (OCC): Curves drawn on certain parameters that determine the sampling plan that will meet the specified performance requirements.

Quality: It is a state in which value entitlement is realized for the customer and provider in every aspect of the business relationship.

Statistical Process Control: Control that monitors quality, and detects and corrects abnormalities through sampling based on the principles of the Central Limit Theorem.

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Statistical Quality Control: Control that provides the basis for the philosophy of total quality management using statistical techniques for control of quality.

4.6 Review Questions

1. What are the attributes to define quality?
2. Philosophy of total quality management or continuous process improvement for improving processes gave rise to two powerful tools. What are those tools?
3. What are the two types of control charts representing the two types of sampling?
4. What is statistical process control?
5. Explain checklists and tally charts as a common method to capture the data.
6. Quality has become a very serious issue in mass production systems, what are the analytical tools used to check the quality?
7. What is the significance of Pareto Chart?
8. 'Control charts are time-sequenced charts showing plotted values of a statistic including a centerline average and one or more control limits'. Explain the statement highlighting the significant usage of control charts.
9. The 'p' chart is set up in essentially the same manner as the 'μ' or X bar chart in the control of variables. What is the usage of 'P' chart?
10. Why Statistical Process Control uses control charts?

Answers: Self Assessment

1.	aesthetics	2.	Safety
3.	value	4.	Serviceability
5.	Durability	6.	control
7.	same	8.	control charts
9.	range	10.	fraction
11.	actual occurrence	12.	nominal
13.	form	14.	data points
15.	relative		

4.7 Further Readings

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Online links

www.iso.org/iso/management_standards.htm

www.iso14000-iso14001-environmental-management.com

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Unit 5: Quality Management

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Objectives

After studying this unit, you will be able to:

- Discuss various significant aspects related to quality management;
- Recognize the concept of total quality management;
- Describe the impression of six sigma methodology;
- Explain the service quality model.

Introduction

With the opening-up of Indian markets to international competition, it has become imperative for the future of Indian business organizations to be competitive and match the standards of

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comparable businesses around the world. Organizations need to work with an ongoing sense of renewal. This is not easy. Many things occur whenever an organization tries to accomplish significant, meaningful improvement. However, these obstacles have to be overcome and quality has to be an area of focus. Increasing focus on quality and improving the quality of products usually results in lower costs and this very often provides a competitive advantage to the firm.

5.1 Quality Management Principles

Sumantra Ghoshal in his book Managing Radical Change talks about the Indian mentality of 'chalta hai' or 'satisfactory underperformance'. This type of company could expect as much as 7 per cent of the goods it received and an equal percentage of products it shipped out to be defective. This type of company, when asked what poor quality costs them, their guess would be about 3-5 per cent of sales. But expert opinions actually calculate the costs of poor quality more like 20-30 per cent.

Table 5.1: Cost of Quality Assurance

Prevention Costs	Appraisal Costs	Internal Failure Costs	External Failure Costs
QC administration and systems planning Quality training Quality planning Special processes planning Quality data analysis Procurement planning Vendor surveys Reliability studies Quality measurement and control equipment Qualification of material New Product review Process control	Quality audits In-process testing Checking labour Laboratory or other measurement services Calibration & Set up for test and inspection Test and inspection material Outside endorsements Maintenance and calibration Field testing Incoming, in process, final inspection	Scrap, at full shop cost Rework, at full shop cost Scrap and rework. Fault of vendor Material procurement Factor contact engineering QC investigations (of failures) Material review activity Repair and troubleshooting	Complaints and loss of customer goodwill Warranty costs Field maintenance and product service Returned material processing and repair Replacement inventories Strained distributor relations Trade Concessions

Can such companies compete with today's value driven companies? They would find it very difficult to compete. Today, the best companies do not count their defects per hundred but per million! Philip Crosby states that the correct cost for a well run quality management program should be under 2.5 per cent. This is happening with a large number of professionally run quality conscious firms.

Example: When Matsushita bought over the TV plant run by Motorola at Quasar, the plant had been running at a rate of 150-180 defects per 100 TV sets. Three years later, under the new management, Matsushita was running the plant at a rate of 3-4 defects per 100 sets. The cost of poor quality dropped from $ 22 million to less than $ 4 million annually, making the loss-making plant profitable. All this did not cost much. Quality improvement was achieved through marginal investments but primarily by innovative employee relations and workplace reorganization.

Though customers consider quality a trade-off, companies that offer low prices with high quality, do not see the trade-off. This is because they do not attribute cost to quality. The consensus is that quality increases profits and reduces costs.

The typical activities of quality assurance that cost the organization are shown in Table above. Costs of poor quality are generally classified into four broad categories. Juran defines three

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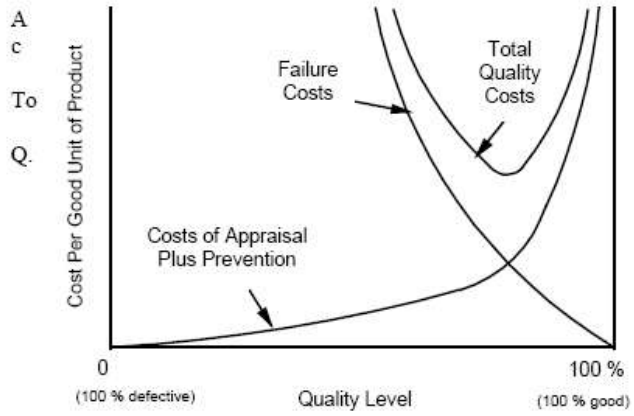
quality zones relative to the point of minimum total quality costs. The "zone of improvement projects" lies below the optimum quality level, while the "zone of perfectionism" lies above it. Between them, and in the area of the minimum total quality costs, lies the "zone of indifference." He identifies the boundary of the zone of perfectionism as lying typically at a quality level where failure costs amount to 40 per cent of the total quality cost. The costs include:

1. Internal Failure Costs,
2. External Failure Costs,
3. Appraisal Costs,
4. Prevention Costs.

Figure 5.1: Juran's Model of Optimum Quality Costs



As can be seen from Juran's model shown in Figure above, the costs of improvement continue to rise whilst the costs of failure continue to fall. Juran suggests relaxing prevention efforts and allowing (even encouraging) increased defect rates in the zone of perfectionism. The principle of diminishing marginal returns in both benefits and effort suggest that a firm should produce where Marginal Revenue is equal to Marginal Cost; but when profit is less than zero, it may be preferable to decrease efforts rather than continue. (In practice, the output units do not have to be single and judgments have to be made in relation to unit or batch size.)

5.1.1 Evolution of Quality Management: Quality Gurus

1. Walter Shewart
   - (i) In 1920s, developed control charts
   - (ii) Introduced expression "Quality Assurance"
2. W. Edwards Deming
   - (i) Developed courses during World War II to educate statistical quality control techniques to engineers and executives of companies that were military suppliers.
   - (ii) After war. Began teaching statistical quality control to Japanese companies.
3. Joseph M Juran
   - (i) Followed Deming to Japan in 1954
   - (ii) Focused on strategic quality planning

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(iii) Quality improvement achieved by focusing on projects to work out problems and securing breakthrough solutions.

4. Kaoru Ishikawa

(i) Promoted use of quality circles

(ii) Developed "Fishbone" diagram

(iii) Emphasized significance of internal customer

5.1.2 Quality Principles

Eight quality management principles have been enunciated by the International Standards Institute (ISO) on which the quality management system standards are based. We will use these principles as our framework to discuss the subject.

The principles that have been derived by the ISO, the Technical Committee on quality management are based on hearings of the committee and from the collective experience and knowledge of international experts. These are given below:

Principle 1 – Customer focus: Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.

Principle 2 – Leadership: Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.

Principle 3 – Involvement of people: People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.

Principle 4 - Process approach: A desired result is achieved more efficiently when activities and related resources are managed as a process.

Principle 5 – System approach to management: Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.

Principle 6 – Continual improvement: Continual improvement of the organization's overall performance should be a permanent objective of the organization.

Principle 7 – Factual approach to decision making: Effective decisions are based on the analysis of data and information.

Principle 8 – Mutually beneficial supplier relationships: An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

These principles give an overview of total quality management and show how, collectively, they can form a basis for performance improvement and organizational excellence. There are many different ways of applying these quality management principles. The nature of the organization and the specific challenges it faces will determine how to implement them. We will discuss many of these aspects in the succeeding sections.

5.1.3 Customer Focus

Customer focus is more than "putting customers first", or finding mutually satisfactory solutions to shared problems, or a dedication to excellence in every sale or service encounter. It also

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requires commitment to forging long-term relationships that create synergies of knowledge, security, and adaptability for both parties.

This is true from the quality concept point of view because quality is defined as what the customer wants. As different customers have different perceptions, quality means different things to different people—it has many dimensions. Customers often evaluate quality citing the attributes of the product or its product delivery process. These are attributes of quality, i.e., the traits associated with quality that can be identified.

Did u know? Quality is the perception of the customer of the degree to which the product meets expectations.

Quality attributes of customers can also be divided into two categories:

1. ***Hard Attributes:*** These are those attributes that must be met by the delivered product or service if it is to be considered satisfactory. There are objective measures to these attributes, e.g., size, colour, weight, cost, reliability, etc. and…
2. ***Soft Attributes:*** These are those attributes that are desirable and have no hard measures. These attributes are based on the 'sense'.

Example: Jet Airways 'approachable, warm and friendly staff', 'being treated as an individual'.

Sometimes, it may be the type and reputation of company one is doing business with.

Attributes, however, are not the same as quality. Identifying every attribute of quality for a product would not, perhaps, describe that product's quality level.

5.1.4 Design Quality and Conformance Quality

Though quality has many dimensions, two terms are commonly used in this context:

Design quality is the inherent quality of the product or service in the marketplace.

Conformance quality refers to the degree to which the product or service design specifications are met.

Freedom from deficiencies refers to the quality of conformance. Increasing the quality of conformance usually results in lower costs, fewer complaints and increased customer satisfaction. Both the quality of design and the quality of conformance should provide products that meet the customer's objectives for those products.

Design quality and conformance quality differ in that design quality is proactive, while conformance quality is reactive. Philip Crosby, the quality guru, believes that ensuring quality should occur primarily at the design phase, i.e., it should be proactive rather than reactive.

Rather than spending time and money on finding and fixing mistakes and errors, Crosby advocates doing a job right at the first time. Crosby challenges organizations to think of how processes can be designed or redesigned to reduce errors and defects to reach a goal of "zero defects". Crosby coined the phrase "quality is free", meaning that the absence or lack of quality is costly to an organization.

Some dimensions of quality, with description, are given in Table below along with the measures of conformance quality both for a manufactured product and a service.

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Table 5.2: Dimensions of Quality and Conformance Quality

Dimensions	Description	Measures	
		Product (Stereo Amplifier)	Service (Jet Airline)
Performance	It is the primary operating characteristics that determine how well the product performs the intended function.	Noise to Signal Ratio, Power	Check-in; System reliability; Baggage handling; On-time record, Safety record
Features	These are qualities that appeal to the customer.	Remote Control; Automatic Balance; Microphone	Customer-contact areas; Lounges; Reservations; City check-in; Through Check-in
Durability	The time before the product needs replacement or has to be repaired. This quality attribute implies product performance under adverse conditions.	Useful life	
Reliability	Expected period of fault free service. The quality associated with a product often increases with the customer's experience of the dependability of the product.	Mean time to failure	Punctuality; Delay handling;
Serviceability	Convenience and cost of repairs that is related to the ease in resolving customer complaints	Modular Design, Service Centers	Availability of airline staff; Responsiveness to individual needs
Aesthetics	A product's appearance, feel, sound, taste, or smell reflects its aesthetics. Aesthetics are hard to define; it is customer specific and sometimes situation specific.	Streamlined Appearance; Range of bright colors, attractive controls	Aircraft cleaning; Staff who are attentive and ready to help; Polite staff
Consistency (Conformance)	The attributes associated with a product should be internally consistent.	Conformance with standards; Matching with documentation	Ticketing
Uniformity	Degree of variations among different products of the same type.	Standard Specifications	Appearance
Safety	This is an attribute of quality that measures the likelihood of harm from a good or service, its impact on health and the environment	Toxicity of materials used, Level of insulation, Power System Controls	Maintenance; Age of Aircraft; ISO 9000
Timeliness	The timeliness for providing the product or service. Some products are perishable, i.e., the quality declines over time. Vegetables fall into this category.	Off-the-shelf availability in Stores	On-time performance
Customer Service	Treatment received by the customer relating to the product before, during, and after completion of the sales transaction.	Ease and cost associated with servicing a product after the sale has been made.	Sales; Being treated as an individual; Approachable warm and friendly staff; Pleasant on-flight Service.
Compatibility	The ability to configure the product with standard or existing interfaces, peripherals or other attachments.	Use with CDs, DVDs, MP3, etc.	Connectivity
Environmental Friendly	This attribute has both societal aspects and is individual specific. The requirements for being considered an environmentally friendly product are becoming more stringent.	Biodegradable materials (firms must now focus on how a product is disposed of after its useful life)	

Performance quality is the most easy to define and customer service is the most difficult to define, both these are crucial components to the long-term survival of most organizations.

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5.1.5 Leadership

According to Steve Forte, the CEO of Jet Airways, "In the service industry, especially the competitive airline industry, knowing WHAT to do is not difficult; the HOW and convincing the team of the WHY is more often the problem.….Doing all the things right in the service profit chain is required. One has to only look at the number of start-up airlines who have not made it in India or anywhere else in the world over the last few years (to understand this)….Without the vision and drive of its founder and Chairman, Naresh Goyal, Jet Airways could easily have been one of the failures."

Quality has often been likened to a state of mind. You may have the best equipment but may not be providing a quality product. The job of management is leadership. It is the leaders who establish unity of purpose and direction of the organization. Management has to create and maintain the internal environment in which people can become fully involved in achieving the organization's quality objectives. It has to lay down the standards with clear responsibility and authority for implementation of the quality program.

Develop a Strategy

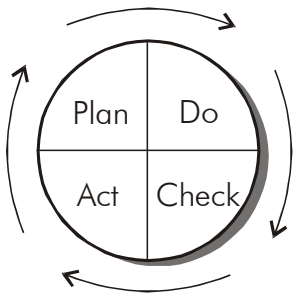
The quality strategy of the organization has to be based on the resources of the organization.

Deming suggested using 'PDCA cycle' as the basis for forming and implementing the quality strategy, while Juran suggested the 'Quality Council' to design and implement the overall quality strategy and 'Vital Few and the Useful Many' concept to identify areas of improvements. These are discussed in this section.

PDCA Cycle

Deming began working in Japan in 1950 and was instrumental in building the Japanese industry into an economic world power. His philosophy was based on the idea that problems in a production process are due to flaws in the design of the system, as opposed to being rooted in the motivation or professional commitment of the workforce. Under Deming's approach, quality is maintained and improved when leaders, managers and the workforce understand and commit to constant customer satisfaction through continuous quality improvement.

Figure 5.2: The PDCA Cycle



To facilitate achieving quality goals, Deming and his colleague, Shewhart, promoted the PDCA cycle—a plan of action to lead the quality movement:

1. Plan
2. Do

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3. Check
4. Act

Plan to implement a policy to improve quality and/or decrease the cost of providing services. After the plan is developed, we do it by putting the plan into action and then check to see if our plan has worked. Finally, we act either to stabilize the improvement that occurred or to determine what went wrong if the gains we planned for did not materialize.

Caution It is to be remembered that any improvement realized by carrying out one PDCA cycle will become the baseline for an improvement target on the next PDCA cycle.

PDCA is a continuous cycle. The process of improvement (PDCA) is never ending, although the dramatic improvements of initial PDCA efforts may be hard to sustain.

Quality Council

Juran developed the idea of instituting a leadership group or "Quality Council", consisting of the organization's senior executive staff and senior management.

Responsibilities of the Quality Council

1. The Quality Council is typically charged with the responsibility for designing the overall strategy for quality planning, control and improvement.
2. It establishes trust and eliminates fear amongst the employees and ensures miscommunication between the various levels of an organization is minimized.
3. It ensures that it provides people with the required resources, training and freedom to act with responsibility and accountability.
4. Quality Improvement activities are seen as important as other management tasks (e.g., budgeting, human resource management, purchasing and training), and leaders can integrate Quality Improvement into every aspect of their operations.
5. Activities are evaluated, aligned and implemented in a unified way. The involvement of senior management advances the objective of the council by inspiring, encouraging and recognizing people's contributions.

Vital Few and the Useful Many

Juran also proposed the idea of the "Vital Few and the Useful Many". The idea is to prioritize which Quality Improvement projects should be undertaken by the organization. In any organization, there can be a lengthy list of possible ideas for improvement. Since the resources to actually implement new ideas are limited, leaders must choose those vital few projects that will have the greatest impact.

The criteria for selecting the projects, according to Juran, should be based on its potential impact on meeting customer needs, cutting waste, or marshaling the necessary resources required by the project.

5.1.6 Involvement of People

The Japanese have a saying: "Every defect is a treasure". The meaning of this maxim is that errors and failures are opportunities for improvement. Errors or problems can help identify

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more fundamental or systemic root causes and ways to improve the system. Yet, fear of identifying problems is often seen as an admission that the current way of doing things is flawed or that those responsible are poor performers. Managers can make sure that it is understood failures contribute to improvement and are opportunities for quality improvements.

Quality Improvement is for People at all Levels

Quality Improvement programs need to be adopted by people at all levels. They are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit. The workforce is the most important component of the organization. The organization cannot function properly without workers who are proud of their work and who feel respected as individuals and professionals.

Managers can help workers be successful by making sure that job responsibilities and performance standards are clearly understood; building strong relationships between management and the workforce; and providing workers with the best tools, instruments, supplies, and information possible.

Did u know? **What are Improvement Teams?**

Improvement teams that include broad representation throughout the organization can help ensure success of initial efforts and create opportunities for cross-disciplinary dialogue and information exchange.

Effective quality management programs go beyond emphasizing one or two efforts or areas to improve performance. Every activity, every process and every job can be improved. Everyone within the organization can be given an opportunity to understand the quality improvement program and their individual role within that effort.

Quality Circles

Quality circles (QCs), like many other innovations in quality improvement, were developed in Japan. QCs are based on the belief that every activity can be improved and this can be done more effectively if the persons on the job put their mind to it. The QCs are deigned to involve employees in quality improvement programs.

Participation in a QC is voluntary, but employees are paid while participating during regular working hours or on overtime. A group leader is selected and trained for the leadership role by the organization, and mentors the participating group in methods of problem solving, analysis, and reporting. The group identifies problems, collects and analyzes data, and also recommends solutions. Those changes that are approved by management are carried out.

Most organizations report cost benefits but more important, it has been found that effective QCs report higher group cohesion, performance norms, job satisfaction and intrinsic satisfaction, satisfaction with co-workers, self-monitoring, and organization commitment.

Barriers between Departments

Barriers between organizations or between departments within one organization are obstacles to effective Quality Improvement. Interdepartmental or intra-organizational friction or lack of cooperation results in waste, errors, delay, and unnecessary duplication of effort.

A continuous and lasting Quality Improvement program requires teamwork that crosses traditional organizational lines. It requires that all workforce members, departments, and units

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share a unified purpose, direction, and commitment to improve the organization. Intra-organizational pathways are developed and cultivated as mechanisms by which to improve performance.

Self Assessment

Fill in the blanks:

1. …… quality management principles have been enunciated by the International Standards Institute (ISO) on which the quality management system standards are based.
2. The criteria for selecting the projects, according to Juran, should be based on its potential impact on meeting customer needs, cutting waste, or …… the necessary resources required.
3. Quality circles in quality improvement were developed in …… .

5.2 Process Approach – Total Quality Management (TQM)

The late 1980's saw a movement away from the concept of quality to that of **Total Quality Management** (TQM). It looked at the entire organization as the unit for implementing quality. It started looking at 'how the organization met these standards'. **Total Quality Management** can be defined as "managing the entire organization so that it excels in all dimensions of products and services that are important to the customer."

TQM is a **process approach** and it is a management strategy. This approach is also used in ISO 9000 standards. When managers use a process approach, it means that they manage the processes that make up their organization, the interaction between these processes, and the inputs and outputs that join these processes together.

Since the process approach is now central to ISO's approach, these processes need to be identified. Below are listed 22 processes that make up a complete ISO 9001: 2000 Quality Management System.

1. Quality Management Process
2. Resource Management Process
3. Continual Improvement Process
4. Customer Communications Process
5. Customer Needs Assessment
6. Document Control Process
7. General Systemic Process
8. Internal Audit Process
9. Internal Communications Process
10. Management Review Process
11. Market Research Process
12. Monitoring and Measuring Process
13. Nonconformance Management Process

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14. Planning Process
15. Product Design Process
16. Product Protection Process
17. Production/Operation Process
18. Purchasing Process
19. Record Keeping Process
20. Regulatory Research Process
21. Service Provision Process
22. Training Process

The processes that make up a quality management system are linked together by many input-output relationships. The following kinds of inputs/outputs connect the processes that make up a quality management system:

- Products
- Services
- Information
- Authorizations
- Comments
- Complaints
- Data
- Decisions
- Documents
- Expectations
- Feedback
- Ideas
- Instructions
- Measurements
- Needs
- Plans
- Proposals
- Records
- Reports
- Requirements
- Resources
- Results
- Solutions

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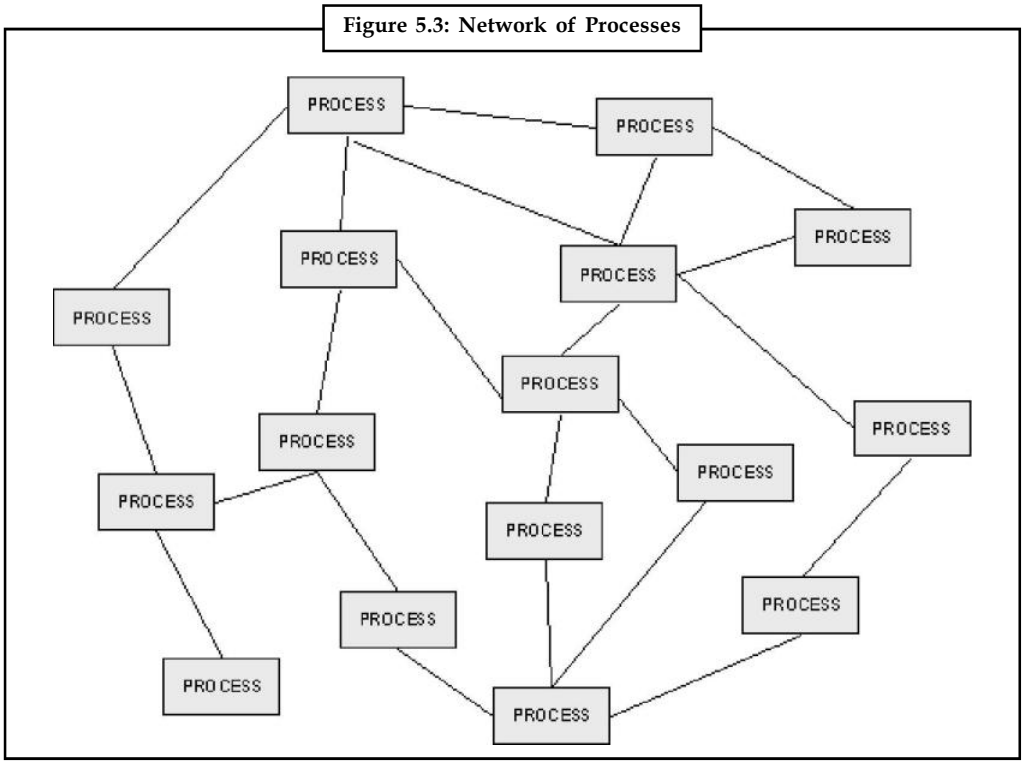
Figure 5.3: Network of Processes



The ISO 9001: 20005 quality management system is made up of processes and input-output relationships. The input-output relationships join the processes together. This turns a loose network of processes into an integrated system. At an abstract level, these processes can be visualized as shown in Figure above. The figure shows several processes interconnected using many lines. These lines represent inputs and outputs.

Self Assessment

Fill in the blanks:

4. TQM is a …… approach and it is a management strategy.
5. Total Quality Management looked at entire organization as the …… for implementing quality.

5.3 Systems Approach to Management

In the late 1980s, Russi Mody, the Chairman, and Dr. J.J. Irani, the Managing Director, of Tata Steel set out on a global search for quality know how. In those days, Tata Steel, a blue chip company, could sell any grade of steel it produced. The marketing function was one of rationing, and consequently quality was not a major issue. Mody and Irani, however, resolved to make better products. They anticipated a change in the business environment and proactively set a strategic goal to make superior quality products.

They contacted the Juran Institute, and through them, their Indian affiliate, Qimpro Consultants. After examining the costs of poor quality, Russi Mody articulated a strategic quality goal: Reduce by half the cost of poor quality in five years. The Juran Institute took up the challenge and with some bellwether projects demonstrated the dramatic results possible with a systemic approach to quality management.

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Following the success of the first five pilot projects, Tata Steel adopted this approach to quality improvement. It built the necessary infrastructure for project identification. It also created an apex council and several divisional quality councils to provide strategic direction, and to focus on executing quality improvement projects. In the year 2000, Tata Steel won the first JRD Quality Values Award, the highest internal recognition for total quality in the Tata Group of Companies.

In ten years, with determination, Tata Steel had achieved excellence in manufacturing. Today, it is the world's second lowest cost producer of hot rolled coils. In July 2001, the company was ranked first among 12 of the world's top steel firms by the US consultancy organization, World Steel Dynamics.

Understanding Relationships among Factors Determining Quality

The Tata management understood that in order to be successful using a systems approach, there are a number of basic steps that need to be taken. First, it had to determine how quality fitted into the overall organizational strategy. Then, more specifically, the role quality played in the processing of the product. Next, the quality theme had to be clarified. It was essential that individuals at all levels within the organization comprehended the quality goals.

For any organization the key elements that affect quality are people, facilities, and materials. We need to understand how they affect quality in the firm. Once a strategy is developed and communicated and the key elements affecting quality are understood, the conversion process needs to be examined.

Self Assessment

Fill in the blanks:

6. The key elements for any organization that affect quality are people, facilities, and …… .
7. After the development and communication of strategy and well understanding of key elements of quality, the …… process needs to be examined.

5.4 Continual Improvement

Continual improvement of the organization's overall performance should be a permanent objective of the organization. Continual improvement comes from a well-established strategy for quality, one that is based on customer perceptions.

We know that quality can be built into all activities and services. Improved efficiency can result from focusing not only on achieving present performance targets, but more importantly, by breaking through existing performance levels to new, higher levels. This can, however, be assured by a continuous search to identify areas of potential improvements.

Improved efficiency and service can result from focusing not only on achieving present performance targets, but more importantly, by breaking through existing performance levels to new, higher levels. A close cooperation between those who provide services and those who consume services is essential.

Such an organization needs not just good people; but also people who are growing through education and life experiences. Management, as well as members of the workforce, must continue to experience new learning and growth. This is the basis for continual improvement. Some techniques, commonly used for continual improvement, are discussed below:

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Kaizen

Continuous improvement as practiced by Japanese firms is called Kaizen. Kaizen seeks continual improvement of machinery, materials, labour utilization, and production methods through applications of suggestions and ideas of company teams. Like Six Sigma (covered in a subsequent section), it also emphasizes the scientific method, particularly hypothesis testing about the relationship between process inputs (X's) and outputs (Y's) using design of experiments (DOE) methods.

Under the maintenance function:

- Kaizen requires the management to first establish policies, rules, directives and standard operating procedures (SOPs) and then
- Work towards ensuring that everybody follows the SOP.
- This is achieved through a combination of discipline and motivational measures.

Under the improvement function,

- Kaizen works continuously towards revising the current standards,
- Once they have been mastered, higher standards are established.

Kaizen signifies small improvements as a result of co-ordinated continuous efforts by all employees. The suggestion system is an integral part of an established management system that aims at involving employees in Kaizen. The number of worker's suggestions is regarded as important criteria in reviewing the performance of the worker's supervisor and the manager of the supervisor.

The Japanese management encourages employees to generate a great number of suggestions and works hard to consider and implement these suggestions, incorporating them into the overall Kaizen strategy. 'Quality Circles' is also part of the Kaizen system. This has been discussed earlier. Management also gives due recognition to employees' efforts for improvement. An important aspect of the suggestion system is that each suggestion, once implemented, leads to an upgraded standard.

Notes Kaizen requires on-the-job training of workers. It ensures that every worker has a thorough understanding of:

1. The needs of those who use and/or pay for the product or services;
2. How to meet those needs; and
3. How to improve the system's ability to meet those needs.

The availability of modern statistical software has made analyzing and displaying data easier. These techniques are used in Kaizen to encourage employees.

Self Assessment

Fill in the blanks:

8. Continual improvement comes from a well-established strategy for quality, one that is based on …… .
9. Continuous improvement as practiced by Japanese firms is called …… .

Notes

5.5 Quality Management Function

Usually, quality control is a staff function independent of production. It is given the responsibility to ensure that the product meets the design specifications, which reflect the requirements of the customers, i.e., minimize the difference between the Design quality and the Conformance quality.

The quality management process is judged by the degree to which the product or service design specifications are met. The department's ability to adhere to quality standards is based on two methods:

(a) Sampling inspection and

(b) Statistical quality control charts.

In the case of inspection, decisions have to be taken:

- Where to Inspect?
- How much to Inspect? and
- How to control inspection costs?

Where to Inspect?

Essential types of inspection include:

(a) Receiving/Incoming Inspection;

(b) In-process inspection;

(c) Final Inspection; and

(d) Equipment and Tooling Inspection.

Incoming Inspection

- Incoming raw material and components are normally inspected at the manufacturer's premise on arrival.
- This inspection not only weeds out material with defects but also determines vendor quality levels.
- Problems often occur due to procuring from less expensive sources. Though high-quality materials are easier to work with than low-quality materials, they often result in a labour savings; this is often overlooked.

Incoming inspection is important to all organizations, but is especially important to organizations that procure a high percentage of their components or parts from outside the firm or consume natural raw materials. There is a trend today for buyers to require vendor certification. This reduces the burden on incoming inspection. In essence, certification makes the vendor a part of the company team as a link in the supply chain.

In-process Inspection

- The inspection of work in-process prevents the continuing production of excessive amounts of defective products.
- Traditional in-process inspection consists of spot checking product quality during processing and 100 per cent inspection of lots at critical points.
- It also involves inspection of the first few pieces of a product-run for a given machine.

Notes

The key factor in production quality is the degree of variation or a piece-to-piece consistency within a material lot and in subsequent lots. This needs to be controlled and this is done by using the inspection information for statistical quality control.

Final Inspection

- The final inspection normally takes place in special areas equipped with all essential inspection instruments.
- The objective of this inspection is that the product that leaves the premises must meet the quality objectives of the firm.

Equipment and Tooling Inspection

- Inspection of equipment and tooling is extremely important to ensure that processes operate properly. Facilities, processes, and equipment also affect quality.

Example: Tools wear out and break, equipment needs to be in good repair and properly calibrated from time to time.

- All these factors affect quality. Tools, jigs, fixtures, gauges, forms and other machine accessories are normally inspected 100 per cent in the tool crib.
- Processing and handling equipment is inspected on the shop floor.

The objective of this inspection is to prevent machine breakdown and production loss.

How much to Inspect ?

There are two types of decisions that are possible:

1. Inspection can be 100 per cent, or
2. Inspection can be done on a sampling basis.

Though 100 per cent inspection is practiced by many firms at critical process junctions or final inspection, there is an increasing tendency in well run organizations to go in for sampling inspection. This involves selecting representative random samples from given lots.

5.5.1 Control of Inspection Costs

Quality must be built into the product during processing. Inspection constitutes a post-mortem judgment of the goodness or defectiveness of a product. The proper amount of inspection, therefore, is the least amount that is necessary.

Did u know? Inspection is a 'deadweight' cost. Inspection cannot improve the quality of the product Deming points out, "Inspection (as the sole means) to improve quality is too late"! *Lasting quality comes not from inspection, but from improvements in the system*.

Example: Documenting deficiencies in record-keeping does not, by itself, generate ideas that would make the task of record-keeping less error-prone. A quality-driven approach might, instead, encourage development of clear and simple record-keeping forms that minimize or eliminate the likelihood of mistakes.

Notes

Quality control should constantly monitor performance for compliance with the original design standards. As inspection and monitoring constitute a post mortem judgment, the effectiveness of quality control is based on identifying where performance falls short of the standard, and put into action plans to deal quickly with the problem. Procedures and records that are essential should be readily accessible by the people who need them and those that add no value should be abandoned. All efforts have to be made to put the system back into a state of 'control', i.e., the way it was designed to operate, with the least number of defects possible.

In service organizations, controlling costs becomes more difficult due to nature of the product. Additional measures have to be taken often to ensure that quality is under control.

Example: Jet Airways not only benchmarks its services, but in order to be able to control its quality control program it has incorporated the following features into it:

- Quality awareness programs for all staff,
- Outstation audits (in-flight and airport),
- Quarterly customer feedback workshop,
- Review of standards (minimum/competitive world-class),
- External measurement of quality.

There are a number of methods to reduce inspection costs.

- Inspection costs can be reduced by using statistical sampling inspection.
- Another option is to increase mechanization and automation of the processes and especially of the inspection procedures.
- Electronic controls are often used to stop a machine and reset it when it gets out of adjustment. This often makes inspection redundant.

The objective should be that the solution reflects a systems approach and provides effective quality control.

5.5.2 Zero Defect Concept

Zero Defects, initiated by Philip Crosby, is a business practice which aims to reduce and minimise the number of defects and errors in a process and to do things correct the first time. The final aim will be to reduce the level of defects to zero. However, this may not be possible and in practice and what it means is that everything feasible will be done to eliminate the likelihood of errors or defects occurring. The in general effect of achieving zero defects is the maximisation of profitability.

More recently the conception of zero defects has lead to the creation and development of six sigma pioneered by Motorola and now takes on worldwide by many other organisations.

How can it be used?

The concept of zero defects can be basically utilised in any situation to improve quality and reduce cost. Though it doesn't just happen, as the right conditions have to be established to allow this to take place. A process, system or technique of working has to be established which allows for the achievement of zero defects. If this process and the connected conditions are not created, then it will not be possible for anyone involved in the process to attain the desired objective of zero defects.

Notes

In such a process it will be possible to determine the cost of none conformance in terms of wasted materials and wasted time.

Caution Any process that is to be designed to take in zero defect concept must be clear on its customer expectations and desires.

The best is to aim for a process and finished article that conforms to customer requirements and does not fall short of or go beyond these requirements. For example, in recent years many financial organisations have made claims regarding how rapidly they can process a home loan application. But what they may have failed to understand is that in spending a great deal of time and money reducing processing time they are over and above customer requirements (even if they consider that they know them). In these cases they have exceeded the cost of conformance when it was not essential to do so.

Advantages

- Cost reduction caused by a reduce in waste. This waste could be both wasted materials and wasted time due to unnecessary rework.
- Cost reduction due to the fact that time is now being spent on solitary producing goods or services that are produced according to the requirements of consumers.
- Building and delivering a finished article that matches to consumer requirements at all times will result in increased customer satisfaction, improved customer retention and augmented profitability.
- Possible to calculate the cost of quality.

Disadvantages

- A process can be over engineered by an organisation in its efforts to build zero defects. Whilst endeavouring to make a situation of zero defects increasing time and expense may be spent in an attempt to construct the perfect process that delivers the perfect finished product, which in actuality may not be possible.

Example: A consumer requirement may be a wish to buy a motor car that is 100% reliable, never rusts and maximises fuel consumption. Though, in this instance, in practice, if an organisation doesn't have some kind of built in obsolescence it will have a more restricted life.

Task Give an example from an organisation about the role played by human behaviour in managing quality.

Self Assessment

Fill in the blanks:

10. The objective of …… inspection is to prevent machine breakdown and production loss.
11. The final aim of Zero Defects will be to reduce the level of defects to …… .

Notes

5.6 Service Quality Model

Due to the nature of the product, the line managers and employees in a service organization are typically responsible for quality control. This is in keeping with the new philosophy that the responsibilities of quality control departments should be given to employees who produce the products. But this system is established in many service industries for other reasons, namely because the product is often produced before the customer. The organization as a system has to interact externally with customers who specify and affect quality at the boundaries of the firm.

Quality control in service firms has to be organized in ways distinctly different from that in manufacturing firms. This is because unlike manufacturing, it often becomes a challenge to design service systems metrics that quantify quality levels in service-oriented companies. Generally, service characteristics are more complex than product characteristics. Customers' desires are generally the basis for quality objectives in service organizations. The characteristics that determine customer acceptance are often intangible. Parameters of service quality include complex customer perceptions such as timeliness, employee's attitudes towards customers, the physical environment where the service is delivered, etc. These requirements, again, can vary widely from individual to individual. Consequently, measuring and controlling quality is more difficult.

Example: in the case of Jet Airways, their research indicated that excellence in the following areas was of vital importance for their airline to be considered an ideal airline: punctuality; safety; seating comfort; large network; friendly and caring; professional and efficient staff/crew service; quality of food served; cleanliness of aircraft; quick baggage clearance; ease in booking tickets; easy check-in.

Though many areas are very difficult to measure, Jet Airways has been able put in place standards for virtually every customer contact. These have been categorized as hard (quantifiable) to soft (intangible) standards.

Hard Standards have been developed 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 are applied to all customer-contact areas. They are designed to present the airline an opportunity to turn ordinary experiences into exceptional services.

Notes

Notes Soft standards have been developed to measure the following aspects of personal service:

- 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,
- Approachable staff,
- Staff who are warm and friendly,
- Being greeted with a smile and pleasant service.

Although soft standards in these areas are subjective and difficult to monitor, they are the standards by which, Jet believes, many customers are likely to judge their services and as such cannot be left to chance. Hard standards have the potential to dissatisfy customers if they are not met. However, Soft standards are powerful tools to impress customers and can be used to make them feel special, to recognize and treat them as individuals.

Like Jet Airways, despite difficulties, the world's best service providers measure almost everything that can be measured. A way of categorizing non-financial service indicators that is catching interest is to refer to them either as upstream or downstream indicators.

Example: Improved quality of service upstream leads to better financial performance downstream.

Table 5.3: Upstream Determinants and Downstream Results

Performance Dimensions	Types of Measures
Competitiveness	Relative market share and position Sales growth, Measures re -customer base.
Financial Performance	Profitability, Liquidity, Capital Structure, Market Ratios, etc.
Quality of Service	Reliability, Responsiveness, Appearance, Cleanliness, Comfort, Friendliness, Communication, Courtesy, Competence, Access, Availability, Security, etc.
Flexibility	Volume Flexibility, Specification and Speed of Delivery Flexibility.
Resource Utilization	Productivity, Efficiency, etc.
Innovation	Performance of the innovation process, Performance of individual innovations, etc.

Notes

Many executives talk freely in terms of quality and standards. Most of these people will be hard-pressed to tell the exact nature of the non-financial measurements that they have in place in their organizations, and what it is, in fact, that is being measured on an ongoing basis. There is a lot of lip service paid to non-financial measures, but it always remains doubtful if they are reliable. Much remains to be done to develop reliable non-financial performance measurement indicators, as these are of great importance to service industries.

Self Assessment

Fill in the blanks:

12. Parameters of service quality include complex customer perceptions which are timeliness, employee's attitudes towards customers and the …… environment where the service is delivered.
13. …… Standards are applied to all customer-contact areas.

5.7 What is Six Sigma?

Six Sigma refers to a disciplined, **data-driven approach** and methodology for eliminating defects in any process—from manufacturing to transactional and from product to service. A defect is a component that does not fall within the customer's specification limits.

Example: In administrative processes, Six Sigma may mean optimizing response time to inquiries, maximizing the speed and accuracy with which inventory and materials are supplied, and fool proofing such support processes from errors, inaccuracies and inefficiency.

Six Sigma

Traditional quality programs focus on detecting and correcting defects. However, Six Sigma programs seek to reduce the variation in the processes that lead to these defects. One of the most important measures of variation is the **standard deviation**. The standard deviation ('s') of a set of sample scores is a measure of variation of scores about the mean, and is defined by the following formula:

$$s = \sqrt{\frac{\sum (x-\bar{x})^2}{n-1}}$$

Where: 'x' is the value of the attribute

'x?' is the mean value, and

'n' is the number of readings

The philosophy underlying Six Sigma is to reduce process output variation. The performance of a process in terms of its variability is compared with different processes using a common metric. This metric is **Defects Per Million Opportunities (DPMO)**. This calculation requires three pieces of data:

1. ***Unit:*** The item produced or being serviced.
2. ***Defect:*** Any item or event that does not meet the customer's requirements.
3. ***Opportunity:*** A chance for a defect to occur.

Notes

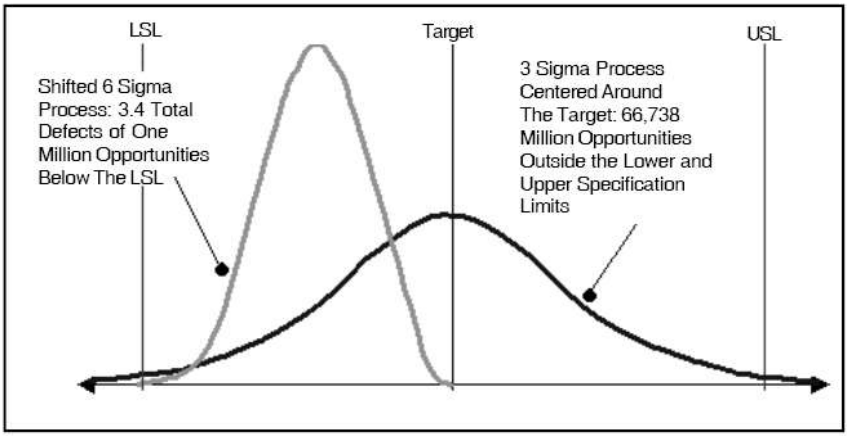
A calculation is made using the following formula.

DPMO = (Number of defects × 1,000,000) / Number of opportunities for error per unit × Number of units

As we have already studied, the control limit of acceptable error of any stream of numbers is ± 3 's' ('s' being the standard deviation). A product is considered acceptable if the variation is ± 3 s on the normal specification. This limits in specifications permit 66,738 defects per million. In Six Sigma, on a long-term basis, no more than 3.4 defect parts per million or 3.4 defects per million opportunities (DPMO) are permitted.

For a Six Sigma process with only one specification limit (upper or lower), there are six process standard deviations between the mean of the process and the customer's specification limit. This is the origin of the name 'Six Sigma'. For a process with two specification limits (upper and lower), this translates to slightly more than six process standard deviations between the mean and each specification limit such that the total defect rate corresponds to equivalent of six process standard deviations. This relationship is shown graphically in Figure 5.4.

Figure 5.4: Six Sigma – A Statistical Representation



A process that is in Six Sigma control will produce no more than two defects out of every billion units. Often, this is stated as four defects per million units which is true if the process is only running somewhere within one sigma of the target specification.

The overall performance of a process, as the customer views it, might be 3.4 DPMO. However, a process could indeed be capable of producing a near perfect output. As the process sigma value increases from zero to six, the variation of the process around the mean value decreases. With a high enough value of process sigma, the process approaches zero variation and is known as 'zero defects'.

There are two aspects to Six Sigma programs: the people side and the methodology side. We will take this up in order.

5.7.1 Six Sigma Roles and Responsibilities

Successful implementation of Six Sigma is based on using sound personnel practices as well as technical methodologies. The roles and responsibilities of different people in a Six Sigma organization are shown in Exhibit 5.1.

Notes

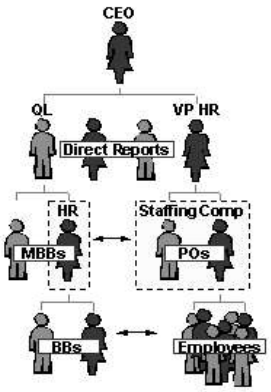
Exhibit 5.1: Roles and Responsibilities in a Six Sigma Organization

To convey the need to vigorously attack problems, professionals are given martial arts titles reflecting their skills and roles:

Quality Leader/Manager (QL/QM): The quality leader represents the needs of the customer. The Quality function is independent from the manufacturing or transactional processing functions to maintain impartiality. The quality leader is generally on the CEO's staff, and has equal authority to all other direct reports.

Master Black Belt (MBB): Master Black Belts are typically assigned to a specific area or function such as marketing or machine shop, die shop, etc. MBBs work very closely and share information with the owners of the process to ensure that quality objectives and targets are set, plans are determined, progress is tracked, and training is provided.

Process Owner (PO): Process owners are responsible for specific processes. For instance, in the marketing department there is usually one person in charge of marketing the chief of marketing is the process owner for marketing. Depending on the size of the business and core activities, there may be process owners at lower levels of the organizational structure. For example, in the marketing department there may be a head of marketing services: that's the process owner.



Black Belt (BB): Black Belts are at the heart of the Six Sigma quality initiative. Their main purpose is to lead quality projects and work full time until they are complete. Black Belts can typically complete four to six projects per year. They also coach Green Belts on their projects.

Green Belt (GB): Green Belts are employees trained in Six Sigma who spend a portion of their time completing projects, but maintain their regular work role and responsibilities.

Source: Adapted from 2000-2005 iSixSigma LLC

Six Sigma needs leaders and 'champions', truly committed to it, to promote it throughout the organization. Corporate wide training in Six Sigma concepts and tools is essential. Professionals in the organization need to be qualified in Six Sigma techniques. MBBs receive in-depth training on statistical tools and process improvement techniques. They must identify appropriate metrics early in the project. They must make certain that the improvement effort focuses on business results that are to be improved. They are the trainers of trainers.

5.7.2 Six Sigma Methodology

While Six Sigma's methods include many of the statistical tools that are employed in other quality movements, DMAIC and DMADV are both special tools developed for Six Sigma applications:

Notes

- Six Sigma methodologies used to drive defects to less than 3.4 per million opportunities.
- Data intensive solution approaches.
- Implemented by Green Belts, Black Belts and Master Black Belts.
- Ways to help meet the business/financial bottom-line numbers.
- Implemented with the support of a champion and process owner.

The Differences of DMAIC and DMADV: DMAIC and DMADV sound very similar, but operate differently. The two methodologies are compared in Table below:

Table 5.4: Differences between DMAIC and DMADV

DMAIC	**Define** **Measure** **Analyze** **Improve** **Control**	• Identify customers and their priorities. • Define the project goals and customer (internal and external) deliverables. Identify CTQs (critical-to- quality characteristics) that the customer considers to have the most impact on quality. • Measure the process to determine current performance. • Identify the key internal processes that influence CTQs and measure the defects currently generated relative to those processes. • Analyze and determine the root cause(s) of the defects. • Improve the process by eliminating defects. • Control future process performance.
DMADV	**Define** **Measure** **Analyze** **Design** **Verify**	• Identify customers and their priorities. • Define the project goals and customer (internal and external) deliverables. Identify CTQs. • Measure and determine customer needs and specifications. • Identify the key internal processes that influence CTQs and measure the defects currently generated relative to those processes. • Analyze the process options to meet the customer needs. • Design (detailed) the process to meet the customer needs. • Verify the design performance and ability to meet customer needs

When to Use DMAIC: The DMAIC cycle is a more detailed version of the Deming PCDA cycle, which consists of four steps - plan, do, check, and act - that underlie continuous improvement. The DMAIC methodology, instead of the DMADV methodology, should be used when a product or process is in existence at your company but is not meeting customer specification or is not performing adequately. The objective here is to modify the process to stay within acceptable range. Determine the control parameters and how to maintain the improvements. Put tools in place to ensure that the key variables remain within the maximum acceptance ranges under the modified process.

When to Use DMADV: The DMADV methodology, instead of the DMAIC methodology, should be used when:

- A product or process is not in existence and the company one needs to be developed.
- The existing product or process exists and has been optimized (using either DMAIC or not) and still doesn't meet the level of customer specification or Six Sigma level.

The objectives of the DMADV methodology finds application in product and process design, or reengineering that have been discussed in earlier units. The design parameters are determined and tools put in place to ensure that the key variables remain within the maximum acceptance ranges under the new or reengineered process.

Notes

Self Assessment

Fill in the blanks:

14. The philosophy underlying Six Sigma is to reduce …… variation.
15. Six Sigma refers to a disciplined, …… approach and methodology for eliminating defects in any process.
16. For a Six Sigma process with only one specification limit, there are …… process standard deviations between the mean of the process and the customer's specification limit.

5.8 Acceptance Sampling

The approach to control production quality level differs somewhat with the type of production involved.

- In jobbing production with its low volume of output to particular technical specifications, emphasis is placed on deciding the appropriate inputs to achieve the desired specifications and setting up the operation correctly and on 100 per cent inspection.
- In high volume production, inspecting the critical characteristics on every item, i.e., 100 per cent inspection, is not very practical. Since uniformity is not possible, the key question is, "How much variation exists in the processes?" The answer begins with the process of selecting representative units of output, called samples. Samples are measured for the key product characteristics, in order to ensure that the specification limits are not exceeded. This is called acceptance sampling and has become a norm in most of these industries.

Sampling by Attribute

When the inspection has to basically decide whether or not the item is within the specified limits, the procedure is called 'sampling by attributes'.

- Attribute sampling merely calls for making a yes-no decision.
- This is done on manufactured parts by means of gauges. These gauges need not be read, they only examine if the critical dimensions are within limits.
- The advantage of attribute counts is that less effort and fewer resources are needed than for measuring variables.
- The disadvantage is that even through attribute counts can reveal that quality of performance has changed it may not be of much use in indicating by how much.
- Attribute sampling can be applied to 'services' also.

Example: A count may be used to determine the proportion of airline flights arriving within 15 minutes of their scheduled times. The count may show that the proportion of airline flights arriving within 15 minutes has declined, but the result may not show how much beyond their scheduled times has decline. The result will not show how much beyond the 15 minute allowance the flights are arriving. For that, the actual deviation from the scheduled arrival, a variable would have to be measured.

Sampling by Variables

When the inspection calls for measuring the critical characteristics on each sample and recording the measurements, it is called 'sampling by variables'.

Notes

- Variable sampling measures product or service characteristics, such as weight, length, volume, or time, which can be measured.

Example: Inspectors at Escorts measure the diameter of tractor engine pistons to determine whether the product adheres to the specifications (within the allowable tolerance) and identity differences in diameter over time.

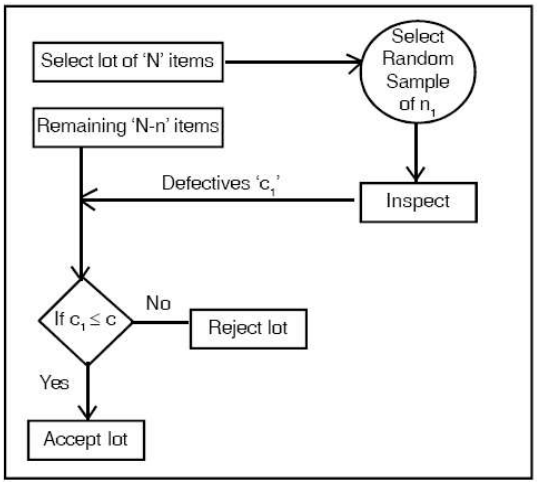
- Variable sampling is more elaborate and expensive compared to attribute sampling.
- It typically involves special equipment, employee skills, exacting procedures, and time, effort and cost.
- But, it is required where the analyst requires actual measurements to draw inferences about the lot and the performance of the operation where it came from, or where the inspection procedure calls for destructive testing.
- In variable sampling, the sample size required for the same level of protection is smaller. This may, in many cases, more than offset the higher unit cost of inspection and result in an overall lower total cost.

A sampling plan is the overall scheme for the acceptance or rejection of a lot based on information gained from a sample. It is used to identify both the size and type of sample and the criteria used to either accept or reject the lot. Different types of sampling plans can be used. These include 'single sampling', 'double sampling' and 'multiple sampling, etc.

Single Sampling Plan

With a single sampling plan, a randomly selected sample of 'n' units is taken from a lot of 'N' units. The quality of each sampled unit is determined and the number of non-conforming samples, 'c1' are compared to a number 'c' is called the acceptance number. If 'c' or more than 'c' sampled units are nonconforming, the entire shipment is rejected. The decision is based solely on the results from a single sample of 'n' units. The schematic diagram is shown in Figure below.

Figure 5.5: Single Method Sampling Plan



Double Sampling Plan

Double sampling is a two-stage process in which the first, a smaller sample is taken. There are two acceptance numbers. The result may be a clear accept decision if the conditions of the first

Notes

acceptance number is met. If the result falls between the two numbers, it is inconclusive and calls for a second sample. After measuring the second sample, the cumulative evidence from both samples leads to either an acceptance or a rejection.

Multiple Sampling Plan

Multiple sampling is generally also called sequential sampling. It is used in continuous, large volume production. This method extends the double-sampling concept. Many samples, each of a very small size, are randomly taken from different lots until the cumulative evidence is conclusive enough to warrant acceptance or rejection. In most applications, multiple sampling requires fewer sample units than double sampling to arrive at the accept-reject decision.

Although both double and multiple-sampling require fewer sample units, they are also more cumbersome to design, implement, and understand. This may explain why single sampling is the preferred method and so frequently encountered in practice.

Self Assessment

Fill in the blanks:

17. When the inspection has to basically decide whether or not the item is within the specified limits, the procedure is called …… .
18. A …… is the overall scheme for the acceptance or rejection of a lot based on information gained from a sample.

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.

Contd...

Notes

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 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,

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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 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

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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 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?

Source: Upendra Kachru, *Production and Operations Management – Text and Cases,* First Edition, Excel Books, New Delhi, 2007.

5.9 Summary

- The Quality costs include Internal Failure Costs, External Failure Costs, Appraisal Costs and Prevention Costs.
- Eight quality management principles have been enunciated by the International Standards Institute (ISO) on which the quality management system standards are based.
- Total Quality Management is managing the entire organization so that it excels in all dimensions of products and services that are important to the customer.
- For any organization the key elements that affect quality are people, facilities, and materials.
- Kaizen seeks continual improvement of machinery, materials, labour utilization, and production methods through applications of suggestions and ideas of company teams.
- The quality management process is judged by the degree to which the product or service design specifications are met.
- Zero Defects, initiated by Philip Crosby, is a business practice which aims to reduce and minimise the number of defects and errors in a process and to do things correct the first time.
- Parameters of service quality include complex customer perceptions such as timeliness, employee's attitudes towards customers and the physical environment where the service is delivered.
- Six Sigma refers to a disciplined, data-driven approach and methodology for eliminating defects in any process—from manufacturing to transactional and from product to service.
- A sampling plan is the overall scheme for the acceptance or rejection of a lot based on information gained from a sample.

5.10 Keywords

Acceptance Sampling: When samples are measured for the key product characteristics, in order to ensure that the specification limits are not exceeded.

Conformance Quality: It refers to the degree to which the product or service design specifications are met.

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External Customers: These are the customers that buy the final product, which pays the organization's bills.

Six Sigma: It is a disciplined, data-driven approach and methodology for eliminating defects in any process-from manufacturing to transactional and from product to service.

Total Quality Management: It can be defined as "managing the entire organization so that it excels in all dimensions of products and services that are important to the customer."

5.11 Review Questions

1. What do you understand by leadership through quality? Examine the case of Jet Airways and explain how they were able to attain a pre-eminent place in the Indian Aviation Industry?
2. What are the principles of quality? Discuss.
3. What is ISO 9000? What are the certification requirements and why do manufacturers get certified? Does it control quality? If so, how?
4. Quality Deployment Function has been widely regarded as a breakthrough in the quality function. Discuss.
5. Select a convenient operation and identify its sources of variation. Describe how each source can result invariability of output quality?
6. Identify different types of inspection and discuss their roles in the quality assurance and control process.
7. What is the relationship between inspection and acceptance sampling?
8. What are the significant differences between quality control in manufacturing and service organization? Explain why these differences exist?
9. What is six sigma methodology of Quality Control?
10. Write short notes on the following:
    (i) Continual Improvement
    (ii) Kaizen

Answers: Self Assessment

1.	Eight	2.	marshaling
3.	Japan	4.	process
5.	unit	6.	materials
7.	conversion	8.	customer perceptions
9.	Kaizen	10.	Equipment and Tooling
11.	zero	12.	physical
13.	Soft	14.	process output
15.	data-driven	16.	six
17.	sampling by attributes	18.	sampling plan

Notes

5.12 Further Readings

Books

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Online links

www.sixsigmaspc.com/six-sigma/sixsigma.html

managementhelp.org/quality/tqm/tqm.htm

www.kaizen.com

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Unit 6: Productivity

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Objectives

After studying this unit, you will be able to:

- Recognize the meaning and scope of productivity;
- Describe the various kinds of productivity measures;
- Explain the different concepts associated with productivity and production.

Introduction

Productivity measurement has emerged as a distinct and separate branch of study in management. A number of studies employing highly sophisticated mathematical and statistical techniques and tools of analysis have been conducted to measure productivity. The importance given to productivity and its measurements is because, in a larger sense, productivity impacts the organization in all areas, and that is what Production and Operations Management is all about.

6.1 The Organization and Productivity

Frederick W. Taylor in his famous book, *The Principles of Scientific Management*, in the chapter on 'Task Study' said, "Human work can be made infinitely more productive not by 'working harder' but by 'working smarter'".

Productivity – the amount of output per unit of input – is a basic yardstick of an organization's health. Productivity is said to be high when more output is derived from the same input, or the same output is obtained from a less input. When productivity is growing, profits tend to rise. When productivity is stagnating, so, generally, is the profit. Organizations, of all sizes and

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types, irrespective of how long they have existed, have potential for productivity improvement. No organization is an exception.

Technically, productivity signifies the ratio between the input and output with respect to given resources, i.e., the ratio of the outputs achieved from an activity to the inputs consumed to make those outputs.

Productivity = Output/Input

This definition, while accurate, does not convey the central role that productivity and productivity improvements have in determining the competitiveness of the organization. Productivity is a multi-faceted concept; no single definition can fully describe it. When more is produced with the same expenditure of resources, it may be termed as effectiveness; when the same amount is produced at less cost, it may be termed as efficiency.

The word 'productivity' is broad enough to cover both. It denotes the efficiency with which the various inputs are converted into goods and services and the effectiveness with which resources are used.

Caution To calculate productivity, it is essential to define and measure the inputs and the outputs for the process or activity.

In simple cases, e.g. a manufacturing operation making a single product on an automatic machine, calculating the productivity of that machine is simple. Let us explore this with an example.

Example: Rewa Engineering manufactures 20,000 components per month by employing 100 workers in one 8-hour shift. What is the productivity of the labour?

Present production = 20,000 Components

Productivity = Output/ Input = Production/ Total man-hours

Assuming 25 working days per month

= 20,000/ 100* 8* 25

Therefore, productivity is 1.0 components/man-hour

Notes **Productivity**

Productivity is a simple concept. It is the amount of output produced per unit of input. It is the value of outputs (i.e., goods and services) produced divided by the values of output resources (i.e., wages and cost of equipment, etc.) used. It is a measure of efficiency.

Productivity can be mathematically expressed as:

Productivity = Output / Input

Productivity Calculations

Compare the productivity of two teams of workers in a machine shop. If the team in 'A' shift produces 400 units in the shift while the team in 'B' shift produces 360 units; then:

Productivity of "A" Team = 400 / 8 = 50 units/hour

Productivity of 'B' Team = 360 / 8 = 45 units/hour

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Productivity measures have been used as tools for business improvement. The success of a business generally depends on its ability to deliver more real value for consumers without using more labour, capital or other inputs.

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. The input/output relationships of the main productivity measures are shown in Table 6.1.

Table 6.1: Various Kinds of 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.

Self Assessment

Fill in the blanks:

1. Productivity is the amount of output per unit of …… .
2. The word 'productivity' is broad enough to cover both efficiency and the …… .
3. Productivity is said to be high when more output is derived from the same input, or the same output is obtained from a …… input.
4. At national level productivity is more important than …… because productivity determines the output while …… just measures the value of the output.
5. Productivity is a …… concept.

6.2 Various Kinds of Productivity Measures

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

6.2.1 Labour Productivity

Labour productivity is a single factor productivity measure (relating a measure of output to a single measure of input). Labor productivity is the quantity of output produced by one unit of

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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. This was explored in the example we attempted earlier.

6.2.2 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'.

Practical Example:

ABC ltd. has two productive units Unit 1 and Unit 2. The Output for Unit 1 is 6000 units and for Unit 2 is 8000 units per month. In unit 1 there are 50 workers working and in unit 2, there are 80 workers working. Each worker is paid the wage of ₹ 100 each per month. The capital, material, energy and other costs for unit 1 and unit 2 is ₹ 5000 and ₹ 8000 per month respectively. The value of 1 unit produce by both the units is ₹ 20. Calculate and compare the multiple factor productivity of both the units of ABC Ltd.

Solution:

$$\text{Multiple factor productivity value of unit 1 (in ₹)} = \frac{6000 \times 20}{(50 \times 100) + 5000} = \frac{120000}{10000} \text{ ₹ } 12$$

$$\text{Multiple Factor productivity value of unit 2 (in ₹)} = \frac{8000 \times 20}{(80 \times 100) + 8000} = \frac{160000}{16000} = \text{₹ } 10$$

Practical Example:

Unitech textiles ltd. has two productive units located at Ludhiana and Varanasi. The Output for Ludhiana Unit is 10000 units and for Varanasi Unit is 8000 units per month. In Ludhiana unit there are 100 workers working and in Varanasi unit, there are 70 workers working. Each worker is paid the wage of ₹ 200 per month at Ludhiana unit and ₹ 250 per month at Varanasi unit. The capital, material, energy and other costs for Ludhiana unit and Varanasi unit is ₹ 20000 and ₹ 12500 per month respectively. The value of 1 unit produce by Ludhiana unit ₹ 200 and Varanasi unit is ₹ 300. Calculate and compare the multiple factor productivity of the Ludhiana and Varanasi units of Unitech textiles ltd.

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Solution:

Multiple factor productivity value of Ludhiana unit (in ₹) = $\frac{10000 \times 200}{(100 \times 200) + 20000} = \frac{2000000}{40000}$ = ₹ 50

Multiple Factor productivity value of Varanasi unit (in ₹) = $\frac{8000 \times 300}{(70 \times 250) + 12500} = \frac{2400000}{30000}$ = ₹ 80

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. This raises three important issues that can complicate how productivity is measured.

- How can you assign rupee values to different outputs within and external to the firm?
- How can multiple inputs with different economic values be included in the measurements?
- How can multiple outputs with different economic values be included in the measurements?

6.2.3 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.

Did u know? 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.

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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.

However, mainly because of the difficulties involved in quantifying various intangible inputs to total factor productivity, labour productivity is far more widely used. It is important to bear in mind that labour productivity is affected not only by capital input but also by other factors which affect the efficient use of both capital and hours of work.

Practical Example:

ABC private ltd. which manufactures steel plates has a plant located at Orissa. It gets the output of 200000 units in 2007 and 270000 units in 2008. The expenses of the company in 2007 is ₹ 80000 and in 2008 ₹ 90000. However the company incurs additional expense of ₹ 10000 for training programme of employees in 2008. Calculate the total factor productivity for the firm and check out whether it is moving satisfactorily in right direction or not?

Solution:

Total factor productivity in year 2007 is = $\frac{200000}{80000} = 2.5$

Total factor productivity in year 2008 is = $\frac{270000}{90000 + 10000} = 2.7$

The total factor productivity for the company is moving in positive direction.

Practical Example:

WLC private ltd. which manufactures iron pipes has a plant located at Rourkela. It gets the output of 1000000 units in 2009 and 1500000 units in 2010. The expenses of the company in 2009 is ₹ 200000 and in 2010 ₹ 220000. In 2010, the company incurs additional expense of ₹ 80000 for in order to solve the dispute among the employee union and management with regard to the creation of employee welfare fund . Calculate the total factor productivity for the firm for both years?

Solution:

Total factor productivity in year 2009 is = $\frac{10,00,000}{2,00,000} = 5$

Total factor productivity in year 2010 is = $\frac{15,00,000}{2,20,000 + 80,000} = 5$

Self Assessment

Fill in the blanks:

6. The measures that are of relevance from the point of view of the operations manager are labour productivity, multiple factor productivity and …… productivity.
7. Economic productivity will depend on pricing and…… .
8. Average economic productivity is computed by dividing output …… by units of input.

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9. ..... productivity is the year-by-year change in the output where a number of factors are taken into consideration.

10. ..... productivity accommodates more than one input factor and more than one output factor when calculating overall productivity.

Caselet

National Productivity Council (NPC)

Understanding economic competitiveness requires continual assessment of economic data and trends from around the world. The competitive position of an organization depends on benchmarking efforts that identify key weaknesses and strengths in the company. This was recognized by the Government of India in 1958 when it established the National Productivity Council (NPC), as a national level organization to promote productivity culture in India. NPC implements productivity promotion plans and programs.

Every company's most important asset is the people who walk in its doors every morning. Talented people, creating new ideas and innovative technologies, keep the companies strong and growing stronger. Productivity consciousness has acquired worldwide momentum. Higher productivity is necessary for the survival of any organization. It stands for proper utilization of available resources to achieve the best results with minimum cost. Improvement in productivity is the only answer to the problems in the industrial sphere and it is the only path to national prosperity. In India, it assumes special significance owing to the resource gap.

In order to overcome the hurdle of shortfall in resources, stepping up of productivity is a must. This is the challenge of NPC which has its headquarters at New Delhi. It also has twelve Regional Directorates, two Regional Offices and two Training Institutes. It provides training, consultancy, research and information in the areas of productivity, industrial engineering, pollution prevention and control, human resource development and various other related fields. A maintenance-cum-training Center has been built at Gandhi Nagar with the assistance of the Government of Gujarat. In all, NPC have 14 offices in India and 207 full time professional consultants.

The activities of the Council are chiefly guided by its basic mission objectives:

- To increase productivity in all spheres of industries and to pave the way for launching productivity drive in all spheres of economic activities of the country;
- To stimulate and promote productivity consciousness by disseminating information regarding productivity techniques and processes;
- To stimulate and facilitate establishment of regional/local and industry-wise productivity organizations; and
- To undertake scientific research activities related to productivity.

As the premier institution for promotion of productivity in India, the professional services are aimed at achieving greater competitiveness, improvement in working conditions and the quality of work life. It is trying to make productivity a mass movement. The ability to succeed in the marketplace remains a cornerstone of competitiveness.

The threats to economic competitiveness that existed two decades ago have been replaced by new challenges—challenges relating to innovation, capacity and competitiveness.

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The concept of productivity encompasses not only a more efficient use of resources, but also of quality, environmental protection and integrated economic and social development.

Mr. Umesh Panjiar, the Director General of NPC, in a meeting with his senior officers was concerned with the changes taking place. Though the directions of the changes were clear, how could one tackle the challenges they posed? He asked Dr. A.K. Saxena, a senior Director in the organization, to suggest ways and recommend changes within the organization that would enable it to meet the new challenges.

6.3 Productivity and Production

The term 'productivity' must not be confused with production. Productivity is a ratio, while production relates to a volume. Increased production does not necessarily mean increase in productivity. If the input of resources goes up in direct proportion to the increase in output, the productivity will remain the same. And if input increases by a greater percentage than output, higher production will be achieved at the expense of a reduction in productivity.

Caution It must be remembered that Productivity calculations are based on the assumption that quality levels are maintained.

If an organization produces more output with the same level of resources, but the quality of the output is lower, then the productivity may not increase. If an organization produces more components, but they are defective and must be rejected, you may have actually reduced productivity.

Cost and quality are characteristics that must be designed into a product in the first place, but achieving them in the final product is the result of carefully managing the productive resources of a company.

6.3.1 Enhancing Productivity

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.

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.

Notes The objectives of improvements in productivity are:

- Efficiency
- Maximum output

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- Economy
- Quality,
- Elimination of waste
- 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. For 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:

- 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.
- The equipment and methods used in the activities.
- 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. 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.

Detail analysis of individual jobs and activities focuses on making people more productive. Analysis might suggest a better way to do the allocated work. An example of this is the placement

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of the work piece referred to earlier. When given a task, most people will, with only a small amount of training, be taught how to make small improvements in their activities to improve productivity. With billions of tasks performed each day in service and manufacturing firms throughout the world, one can visualize the impact of these kinds of improvements on productivity and costs.

Figure 6.1: The Productivity Tree

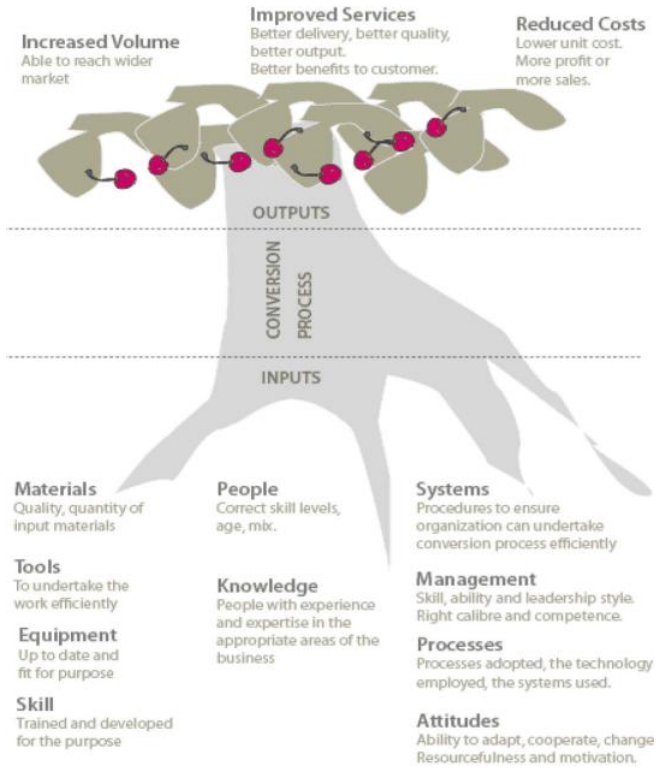

Figure above, illustrates the different components that go into the transformation process. These components need to be looked at in greater detail to identify the potential for productivity enhancements. They can lead to several approaches that can be used separately or in combination to increase productivity.

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 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.

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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.

Did u know? 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.

6.3.2 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.

Notes

Did u know? **What is Productivity Paradox?**

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.

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.

Task Consider the balance sheet of a company for two successive years. Analyze it from the productivity point of view. Using this as the basis, show the advantages and limitations of the productivity measures.

Self Assessment

Fill in the blanks:

11. Productivity is a ratio, while production relates to a …… .
12. Productivity applies …… to the blue-collar workforce as to people doing intellectual work.
13. The productivity tree is shown in three parts, the roots, the trunk and …… .
14. Cost and …… are characteristics that must be designed into a product in the first place.
15. Technology to improve physical productivity focuses on understanding the diffusion of technology in use and …… of processes that exist within and between companies.

6.4 Summary

- Productivity signifies the ratio between the input and output with respect to given resources.
- Productivity data is available from different sources for national productivity, for sector-wise as well as industry-wise performance.

Notes

- The measures that are of relevance from the point of view of the operations manager are labour productivity, multiple factor productivity and total factor productivity.
- Labor productivity is the quantity of output produced by one unit of production input in a unit of time.
- Multiple Factor Productivity is the productivity achieved when more than one input or inputs are consumed to make the outputs.
- Total Factor productivity is the year-by-year change in the output where a number of factors are taken into consideration.
- Productivity is a ratio, while production relates to a volume.
- Economies of scale allow firms to increase productivity by making operations larger.
- Technology determines both the maximal physical quantity of output that can be reached as well as the number and the quality of inputs required.
- Productivity applies equally to the blue-collar workforce as to people doing intellectual work.

6.5 Keywords

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

Multiple Factor Productivity: Productivity achieved when more than one input or inputs is consumed to make the outputs. The outputs are measured either in money terms or the number of units produced.

Production: Measure of the volume of output achieved.

Productivity: Ratio of the outputs achieved from an activity to the inputs consumed to make those outputs.

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

6.6 Review Questions

1. Define the term 'productivity'.
2. Productivity is a basic yardstick of an organization's health. Explain.
3. How is it different from production?
4. What measures would you suggest to improve productivity of a firm? Give examples.
5. Explain how the nature of work has changed, and describe how that is affecting productivity.
6. How do computers and information technology impact productivity?
7. What are the major dissimilarities in the productivity aspect of manufacturing and service firms?
8. If an organization produces more output with the same level of resources, but the quality of the output is lower, in this case what will be the state of productivity?
9. Differentiate among the various kinds of productivity measures?
10. Is productivity a simple concept or a multifaceted concept? Give practical illustrative reasons in support of your answer.

Notes

Answers: Self Assessment

1.	input	2.	effectiveness
3.	less	4.	money, money
5.	multi-faceted	6.	total factor
7.	demand	8.	value
9.	Total Factor	10.	Multiple factor
11.	volume.	12.	equally
13.	the fruit	14.	quality
15.	redesigning		

6.7 Further Readings

Books

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Online links

tutor2u.net/business/production/just-in-time.html

wws5.com/in_costprices

Notes

Unit 7: Efficiency and Effectiveness

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Objectives

After studying this unit, you will be able to:

- Explain the implication of business process reengineering;
- Recognize the goals and objectives of benchmarking;
- Discuss the activities of organisation for attaining excellence;
- Describe the TATA business excellency model.

Introduction

For any organization the key elements that affect quality are people, facilities, and materials. We need to understand how they affect quality in the firm. Once a strategy is developed and communicated and the key elements affecting quality are understood, the conversion process needs to be examined. A process is made up of people, work, activities, tasks, records, documents, forms, resources, rules, regulations, reports, materials, supplies, tools, equipment, and so on—all the things that are needed to transform inputs into outputs. An organization, in order to be successful needs to demonstrate continuously that customer satisfaction and organizational processes are its topmost priority, to those responsible for value creation.

Notes

7.1 Business Process Reengineering

A central question in resource allocation is how the existing resources and competencies of the organization can be adapted to fit new strategies. Strategic re-engineering focuses on designing the organization to create a dramatic improvement in performance. This is accomplished by undertaking strategic initiatives at the start of the reengineering process that seek to provide understanding of the markets, competitors, and the position of the organization within the industry so as to change existing business practices. Before the re-engineering of the business processes are carried out, critical success factors required to compete are identified and prioritized. Only then are the individual business processes addressed. Some of the important factors that need to be considered in the re-engineering effort are given below:

- Place the customer at the centre of the reengineering effort — concentrate on reengineering fragmented processes that lead to delays or other negative impacts on customer service.
- BPR must be "owned" throughout the organization, not driven by a group of outside consultants.
- Case teams must be comprised of both managers as well as those will actually do the work and should also be sponsored by top executives of the board.
- BPR projects must have a timetable.
- BPR must incorporate the organizational culture and must emphasize constant communication and feedback.

The organization may sometimes choose to manufacture and market a new product range through a new division or even a new company to avoid problems of conflict or incompatibility with existing operations. In such a case, planning of resources requires structural considerations and may also lead to issues of managing change.

An assessment of a fit between the strategy and the existing resources and competencies establishes the extent to which implementation is likely to require major changes within the organization, or is achievable by an adjustment of the current resource base and competencies.

Did u know? **What makes a system?**

Whenever several processes are interconnected using such input-output relationships, it makes up the system.

Arvind Mills redesigned the value-delivery system for jeans. Arvind, the world's fifth-largest denim manufacturer, found domestic denim sales limited because jeans were neither affordable nor widely available. At ₹ 1000 to ₹ 2000 a pair, they were beyond the reach of the mass market. In 1995, they introduced 'Ruf n Tuf'—a ready-to-stitch kit of jeans components priced at about ₹ 300. Arvind Mills distributed them through tailoring outfits, whose self-interest motivated them to market the kits to create demand for sewing services. 'Ruf 'n Tuf' are now the largest selling jeans in India, driving sales in Arvind's main product, denim, and netting the company a potentially powerful consumer brand.

Task "Organization through Business process reengineering can handle their change management implications in operations and planning". Give some practical examples of the organization that applied the Business process reengineering concept in managing the change for effectiveness.

Notes

Self Assessment

Fill in the blanks:

1. …… focuses on designing the organization to create a dramatic improvement in performance.
2. Before the re-engineering of the business processes are carried out, critical success factors required to compete are identified and ……
3. BPR must incorporate the organizational culture and must emphasize constant communication and …… .
4. An assessment of a fit between the strategy and the existing resources and …… establishes the extent to which implementation is likely to require major changes within the organization.

7.2 Benchmarking

In the early eighties, the Mexican Government expanded the capacity of steel mill based on the DRI process, Imexsa, at Lazoro Cardenas, to 2 million tons. Three years after expansion and after having absorbed significant losses, the government then decided to privatize the facility. Ispat International N.V. is owned by the Mittals, registered in Holland and headquartered in London. It is one of the most successful Indian led enterprises. Ispat was invited and successfully won the bid for the ownership of the facilities, in January 1992.

The new management started to benchmark the operating processes. Team members looked at the best practices within the Ispat network, the steel industry as a whole, and also identified and studied related processes at global leaders such as Ericsson and General Electric. They collected and analyzed detailed volume, cost, quality and productivity data for each step in the production process on a daily basis. Ispat started implementing the recommendations. By 1998 the annual steel shipments had increased to over 3 million tons; productivity had improved from 2.62 to 0.97 man-hours per ton. J.P. Morgan and Credit Suisse First Boston reported Imexsa as the lowest cost slab producer in the world.

Successful companies in every industry engage in a variety of practices, which lead to achievement of high level performance. Benchmarking has become one of the most popular tools of business management in corporate attempts to gain and maintain competitive advantage. The central essence of benchmarking is about learning how to improve business activity, processes and management. However, benchmarking as a term has been used widely to refer to many different activities. There is a wide variation in definitions used to describe 'benchmarking'. Some of the definitions are given below to highlight the diversity:

- "A continuous systematic process for evaluating the products, services and work of organizations that are recognized as representing best practices for the purpose of organizational improvement" (Spendolini, 1992).
- "A continuous search for, and application of, significantly better practices that lead to superior competitive performance" (Watson, 1993).
- "A disciplined process that begins with a thorough search to identify best-practice-organizations, continues with the careful study of one's own practices and performance, progresses through systematic site visits and interviews, and concludes with an analysis of results, development of recommendations and implementation" (Garvin, 1993).
- "Benchmarking is an external focus on internal activities, functions, or operations in order to achieve continuous improvement" (McNair and Leibfried, 1992).

Notes

- "Benchmarking is systematic and continuous measurement process: a process of continuously measuring and comparing an organizations business processes against process leaders anywhere in the world to gain information which will help the organization to take action to improve its performance" (APQC/IBC cited in Watson, 1993, p. 3).

Notes The characteristics of benchmarking are:

- Measurement via comparison;
- Continuous improvement;
- Systematic procedure in carrying out benchmarking activity.

7.2.1 The Benchmarking Process

Benchmarking involves looking outside a particular business, organization, industry, region or country to examine how others achieve their performance levels and to understand the processes they use. In this way benchmarking helps explain the processes behind excellent performance. When the lessons learnt from a benchmarking exercise are applied appropriately, they facilitate improved performance in critical functions within an organization or in key areas of the business environment.

Application of benchmarking involves four key steps:

1. Understand in detail existing business processes,
2. Analyze the business processes of others,
3. Compare own business performance with that of others analyzed,
4. Implement the steps necessary to close the performance gap.

Caution Benchmarking should not be considered a one-off exercise. To be effective, it must become an ongoing, integral part of an ongoing improvement process with the goal of keeping abreast of ever-improving best practice.

7.2.2 Types of Benchmarking

There are a number of different types of benchmarking, as summarized below:

1. ***Strategic Benchmarking:***

   (i) Where businesses need to improve overall performance by examining the long-term strategies and general approaches that have enabled high-performers to succeed.

   (ii) It involves considering high level aspects such as core competencies, developing new products and services and improving capabilities for dealing with changes in the external environment.

   Changes resulting from this type of benchmarking may be difficult to implement and take a long time to materialize.

2. ***Performance or Competitive Benchmarking:***

   (i) Businesses consider their position in relation to performance characteristics of key products and services.

Notes

(ii) Benchmarking partners are drawn from the same sector.

This type of analysis is often undertaken through consultants to protect confidentiality.

3. ***Process Benchmarking:***

(i) Focuses on improving specific critical processes and operations.

(ii) Benchmarking partners are sought from best practice organizations that perform similar work or deliver similar services.

(iii) Process benchmarking invariably involves producing process maps to facilitate comparison and analysis.

This type of benchmarking generally results in short term benefits.

4. ***Functional Benchmarking:***

(i) Businesses look to benchmark with partners drawn from different business sectors or areas of activity to find ways of improving similar functions or work processes.

(ii) This sort of benchmarking can lead to innovation and dramatic improvements.

5. ***Internal Benchmarking:***

(i) It involves benchmarking businesses or operations from within the same organization.

(ii) Internal benchmarking provides access to sensitive data and information; standardized data is often readily available; and, usually less time and resources are needed.

There may be fewer barriers to implementation as practices may be relatively easy to transfer across the same organization. However, real innovation may be lacking and best in class performance is more likely to be found through external benchmarking.

6. ***External Benchmarking:***

(i) It involves analyzing outside organizations that are known to be best in class.

(ii) External benchmarking provides opportunities of learning from those who are at the "leading edge".

This type of benchmarking can take up significant time and resource to ensure the comparability of data and information, the credibility of the findings and the development of sound recommendations.

7. ***International Benchmarking:***

(i) Best practitioners are identified and analyzed elsewhere in the world.

(ii) Benchmarking partners should be chosen such that they produce valid results.

Globalization and advances in information technology are increasing opportunities for international projects. However, the results may need careful analysis due to national differences.

7.2.3 Benchmarking Helps in Strategic Management Process

Evaluation and improvements are important parts of the strategic management process. How do we judge our performance in any area of operation? This is done by 'benchmarking'.

- Benchmarking is the process of identifying 'best practice' in relation to both products (including) and the processes by which those products are created and delivered.

Notes

- Are there lessons to be learned from others?
- Understand and evaluate the current position of a business or organization in relation to 'best practice' and identify areas and means of performance improvement.
- Benchmarking provides a clear signal of success or failure of the firm's competence to compete effectively in the competitive arena.
- Benchmarking is often used to identify and develop core competencies and competitive advantage.

Table 7.1: Core Competencies and Benchmarking

Type	Description	Most Appropriate for
Strategic Benchmarking	Comparing with long-term strategies and general approaches of high-performers to improve overall performance.	Realigning business strategies that have become inappropriate
Performance or Competitive Benchmarking	Businesses consider their position in relation to performance characteristics of **key products and services**. Benchmarking partners are drawn from the same sector.	Assessing relative level of performance in key areas or activities in comparison with others in the same sector and finding ways of closing gaps in performance
Process Benchmarking	Focuses on improving specific **critical processes and operations**.	Achieving improvements in key processes to obtain quick benefits
Functional Benchmarking	Businesses look to benchmark with partners drawn from different business sectors or areas of activity to find ways of improving similar functions or work processes.	Improving activities or services for which counterparts do not exist.
Internal Benchmarking	Involves benchmarking businesses or operations from within the same organization (e.g., business units in different countries).	Several business units within the same organization exemplify good practice and management want to spread this expertise quickly, throughout the organization
External Benchmarking	Involves analyzing outside organizations that are known to be best in class.	Where examples of good practices can be found in other organizations and there is a lack of good practices within internal business units
International Benchmarking	Best practitioners are identified and analyzed elsewhere in the world.	Where the aim is to achieve world class status or simply because there are insufficient 'national' businesses against which to benchmark.

Self Assessment

Fill in the blanks:

5. …… benchmarking generally results in short term benefits.
6. …… Benchmarking involves benchmarking businesses or operations from within the same organization.

Notes

7. Changes resulting from …… benchmarking may be difficult to implement and take a long time to materialize.
8. Application of benchmarking involves …… key steps.

7.3 Pursuit of Excellence in Organizations

For tracking down fineness or excellence, organizations follow the following techniques:

- Analyzing Cost time trade off
- Using project software

7.3.1 Analyzing Cost Time Trade Off

Organization has as its objective, optimizing a system where "Cost is a function of performance, time, and scope". By determining the network and the critical path, the scope of the project has been completely defined, as the assumption in developing the CPM network has been that resources are available.

However, once you have determined that the end date can somehow be met, you must see whether your unlimited resource assumption has overloaded your available resources. When you assess your resources, remember that nobody is available to do productive work more than 80 per cent of a workday. You lose 20 per cent to personal time, fatigue, and delays.

Caution You also need to examine the network to keep project costs at acceptable levels. This is almost always as important as meeting schedule dates.

There are always Time-Cost Trade-offs. If you want to schedule within the available float, it is called time-critical resource leveling, because time is of essence for your project.

If you minimize resources and continue sliding tasks over until resources become available, even if it means slipping the end date, it is called resource-critical leveling.

Example: A project can often be completed earlier than scheduled by hiring more workers or running extra shifts or using additional equipment. Such actions could be advantageous if savings or additional revenues accrue from completing the project early.

There are a number of possibilities. There are three areas to examine.

- You should first see whether any task has enough float to allow it to be delayed until resources become available.
- You should also ask whether you can reduce scope, change the time limit, or reduce performance. Usually performance is not negotiable, but the other areas may be.

Example: Sometimes you can reduce scope, and the project deliverable will still be acceptable to the client.

Cost to Crash

Total project costs are constituted of direct costs, indirect costs, and penalty costs. The sum of these costs is the total project cost. These costs depend on activity times and project completion times.

Notes

- Direct costs include labour, materials, equipment and any other costs directly related to project activities.
- Indirect costs include administration, depreciation, financial costs, and other variable overheads. Indirect costs can be avoided by reducing total project time. The shorter the duration of the project, the lower will be the indirect costs.
- Penalty clauses are often part of project contracts if the project extends beyond some specific date. Sometimes a bonus may be provided for early completion. Some activities can be expedited to reduce overall project completion time and total project costs.

Time cost Trade-off procedures make use of some special terms. Some of these are explained here below:

Normal Activity Time-Cost-Point

Is the lowest point on a time-cost graph and represents the absolute minimum cost for accomplishing the activity in normal time. Normal Time is the shortest time to perform the activity within the constraint of minimum direct cost.

Feasible Activity Time-Cost Trade-Off Points

Represent the various combinations of minimum direct costs and their corresponding least timings for one individual activity only. There can be few or several of these points and they can be best represented on a graph showing cost versus timings:

(i) The project duration is too long.

(ii) The customer wants to know the additional costs for saving part of the project completion time.

(iii) The company may like to minimize the sum of direct and indict project costs without disturbing the stipulated duration time.

Because the project indirect costs can be easily determined through existing accounting practices, Time-Cost Trade-off procedures are mostly used for minimizing direct costs for the given project duration times only.

The procedure for 'Feasible Activity Time Cost Trade-off' consists in collecting first cost data for the network and rescheduling of all the critical and near critical activities, again collecting second cost data and rescheduling the new critical or sub-critical activities and so on. A systematic procedure has been developed by Burgess.

- Starting with the bottom activity, the method makes comparisons between the sums of squares of daily resource requirements and selects the one with minimum sum.
- The target always being toward reducing the project duration time with minimum increase Direct Costs.
- The process is continued till a step is reached when increase in Direct Cost is less than the decrease in Indirect Costs. That means no further decrease in Total Costs is possible.
- This method of choosing the schedule, leads to the least variation in resource requirements. This is also called 'crashing'.

Notes

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 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

Contd...

Notes

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

7.3.2 Using Project Software

For large projects, assistance of computer software is essential. The software creates a project schedule by superimposing project activities, with their precedence relationships and estimated duration time, on a time line. It provides information on the specific tasks, and milestones to know whether the project is on target, headed in the right direction, and on time. People doing the work will find it much easier to see when they are supposed to start and finish their jobs if you give them a bar chart compared to the arrow diagram.

Did u know? Scheduling software always allows you to print a bar chart, even though a CPM network is used to find the critical path and to calculate floats.

Microsoft Office Project Professional 2003 is a popular software used to plan projects, though many experts are critical of it. The software schedules a task's Start and Finish. It takes into account many factors, including task dependencies, constraints, and interruptions, such as holidays or vacation days.

How to Use

- To start a typical project click on File in the toolbar and then select New.
- A dialog box appears on the screen asking you whether to start a blank project or not. Click on OK.
- A new dialog box appears asking you to fill in the project information.
- Upon clicking the OK button in the Project Information dialog box we have the Gantt chart on the screen.
- Enter tasks in the order they will occur.
- Then estimate how long it will take to complete each task.
- In the Duration field, type the amount of time each task will take in months, weeks, days, hours, or minutes, not counting non-working time. Microsoft Project uses durations to calculate the amount of work to be done on the task. When you start a new project in Microsoft Project, you can enter your project's start or finish date, but not both.
- Double-click on the first row of the field Task Name.
- A dialog box appears asking for Task Information. Information about predecessors, resources, etc., has to be keyed in.
- You link tasks by defining a dependency between their finish and start dates.

Notes

Example: The "Pick up Trash" task must finish before the start of the "Mow Front" task in the Garden project.

There are four kinds of task dependencies in Microsoft Project:

Finish-to-start (FS)	Task (B) cannot start until task (A) finishes.
Start-to-start (SS)	Task (B) cannot start until task (A) starts.
Finish-to-finish (FF)	Task (B) cannot finish until task (A) finishes.
Start-to-finish (SF)	Task (B) cannot finish until task (A) starts.

- You can schedule your tasks most effectively by entering task durations, creating dependencies between tasks, and then letting Microsoft Project calculate the start and finish dates for you.
- You can also specify lags between activities.
- As you keep on filling the information about the tasks, the Gantt chart is automatically created.
- You can track actual work using the time-phased fields in Microsoft Project.
- To keep your project on schedule, make sure that tasks start and finish on schedule.
- The Tracking Gantt view helps find trouble spots, tasks that vary from the baseline plan. You can then adjust task dependencies, reassign resources, or delete some tasks to meet your deadlines.
- The Tracking Gantt view pairs the current schedule with the original schedule for each task.
- When you've saved the project with a baseline, but before you've entered actual data on progress, the Tracking Gantt view shows tasks with the baseline bars and the scheduled or actual bars synchronized.
- When you update your schedule, you can compare the baseline plan to your actual progress to identify variances.
- You can click the Network Diagram button on the left on the main screen and the network diagram will be displayed.
- If you click on the Resource Sheet button given in the left column of the screen, the resource sheet is displayed. You can fill in your resource requirements. It takes the maximum number of units of a resource, by default, as unity (100%). It has a feature called Resource Leveling.
- In the Gantt chart view, click on the Tools pull-down menu. Choose the Resource Leveling option.
- A dialog box appears, choose the Automatic radio button. There are three leveling options are given. Click on the Level Now button after choosing one or more leveling options and program reallocates resources, which can be seen both in the Gantt chart as well as the resource sheet.
- If you schedule tasks based on the availability of resources, track the progress of your tasks by updating the work completed on a task. Using this approach, you can track the work that each resource is performing.

Notes

Self Assessment

Fill in the blanks:

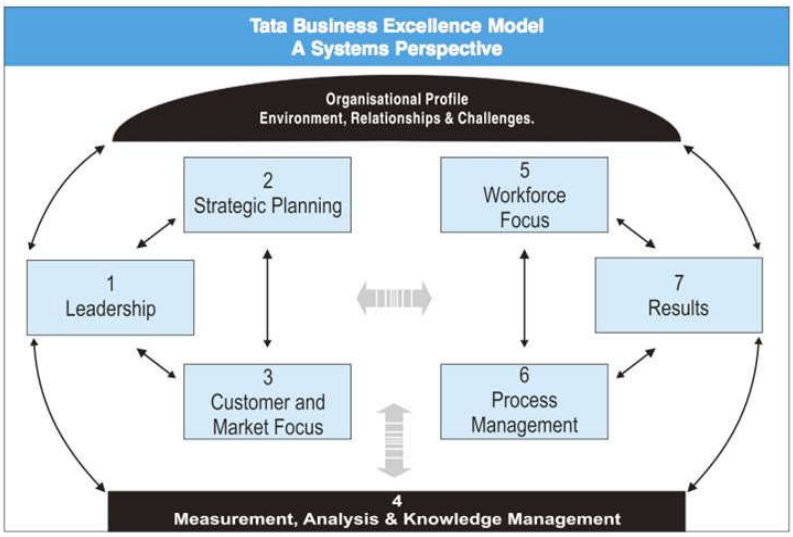
9. Total project costs are constituted of direct costs, indirect costs, and …… costs.
10. Organization has as its objective, optimizing a system where Cost is a function of performance, time, and …… .
11. The software creates a project schedule by superimposing project activities, with their precedence relationships and estimated duration time, on a …… .
12. …… is a popular software used to plan projects.

7.4 TATA Business Excellency Model (TBEM)

TBEM is a 'customised-to-Tata' adaptation of the worldwide renowned Malcolm Baldrige model. The TBEM philosophy has been moulded to deliver a amalgamation of strategic direction and concerted effort to maximise business performance. The model spotlights on seven core aspects of operations: leadership, strategic planning, customer and market focus, measurement, analysis and knowledge management, human resource focus, process management and business results. Performance is calculated in absolute points; companies have to achieve a minimum of 500 points (out of 1,000) within four years of signing the BEBP agreement. Successes are awarded by recognition across the Group.

Notes TQMS helps Tata companies use the model to get insights on their business strengths and opportunities for improvement. This is managed through an annual process of assessment and assurance. The model, all the way through its regular and calibrated updates, is used by Tata companies to keep on in step with the ever-changing business environment.

Figure 7.1: Performance Excellence Framework



Source: http://www.tataquality.com/ui/APage.aspx?SectionId=030509113939212431

Notes

7.4.1 TBEM Criteria Purpose

Tata Business Excellence Model (TBEM) is the foundation for conducting organisational assessments and for giving feedback to applicants. In addition, the Criteria have three significant roles in strengthening competitiveness:

- To help perk up organisational performance practices, capabilities, and results;
- To make easy communication and sharing of best practices information among organisations of all types;
- To provide as a working tool for understanding and managing performance and for guiding; organisational planning and opportunities for learning.

7.4.2 TBEM based Performance Excellence Goals

TBEM Criteria is designed to assist organisations use an integrated approach to organisational performance management that results in:

- Delivery of ever-improving worth to customers and stakeholders, contributing to organisational sustainability;
- Improvement of on the whole organisational effectiveness and capabilities;
- Organisational and personal learning.

7.4.3 The TBEM Model

Category 1: Leadership

Leadership addresses how your senior leaders direct and sustain your organisation, setting organisational vision, values, and performance expectations. Attention is specified to how your senior leaders communicate with your workforce, build up future leaders, measure organisational performance, and create an environment that support ethical behaviour and high performance. The Category also includes your organisation's governance system and how it ensures ethical behaviour and practices first-class citizenship.

Category 2: Strategic Planning

Strategic Planning deals with strategic and action planning, deployment of plans, how adequate resources are ensured to realize the plans, how plans are changed if circumstances require a change, and how accomplishments are measured and sustained. The Category stresses that long-term organisational sustainability and your bloodthirsty environment are key strategic issues that need to be integral parts of your organisation's overall planning. While many organisations are more and more adept at strategic planning, plan execution is still a important challenge. This is especially true given market demands to be agile and to be prepared for unexpected change, for instance disruptive technologies that can upset an otherwise fast-paced but more predictable marketplace. This Category highlights the call for to place a focus not only on developing your plans but as well on your capability to execute them.

Category 3: Customer and Market Focus

Customer and Market Focus addresses how your organisation seeks to recognize the voice of the customer and of the marketplace, with a focal point on meeting customers' requirements,

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needs, and expectations; delighting customers; and building loyalty. The Category stresses relationships as an imperative part of an overall listening, learning, and performance excellence strategy. Your customer satisfaction and dissatisfaction results provide imperative information for understanding your customers and the marketplace. In many cases, such results and trends provide the mainly meaningful information, not only on your customers' views but also on their marketplace behaviours (e.g., repeat business and positive referrals) and how these views and behaviours may put in to the sustainability of your organisation in the marketplace.

Category 4: Measurement, Analysis and Knowledge Management

The Measurement, Analysis, and Knowledge Management Category is the major point within the Criteria for all key information about successfully measuring, analysing, and improving performance and managing organisational knowledge to drive perfection and organisational competitiveness. In the simplest terms, Category 4 is the "brain centre" for the coalition of your organisation's operations with its strategic objectives. Central to such use of data and information are their quality and availability. In addition, since information, analysis, and knowledge management might themselves be prime sources of competitive advantage and productivity growth, this Category as well includes such strategic considerations.

Category 5: Workforce Focus

Workforce Focus addresses key workforce practices-those directed in the direction of creating and maintaining a high-performance workplace and on the way to engaging your workforce to enable it and your organisation to adapt to alter and to succeed. The Category covers workforce engagement, development, and management in an integrated way (i.e., aligned with your organisation's strategic objectives and action plans). Your workforce focal point includes your capability and capacity needs and your workforce support climate. To reinforce the fundamental alignment of workforce management with overall strategy, Criteria also covers human resource planning as part of on the whole planning in the Strategic Planning Category

Category 6: Process Management

Process Management is the central point within the Criteria for your key work systems and work processes. Built into the Category are the vital requirements for identification and management of your core competencies to attain efficient and effective work process management: effective design; a prevention orientation; linkage to customers, suppliers, partners, and collaborators and a spotlight on value creation for all key stakeholders; operational performance; cycle time; emergency readiness; and evaluation, continuous improvement, and organisational learning. Agility, cost reduction, and cycle time reduction are more and more significant in all aspects of process management and organisational design. In the simplest terms, "agility" refers to your ability to adapt quickly, flexibly, and effectively to changing requirements. Depending on the personality of your organisation's strategy and markets, agility might mean rapid change from one product to another, rapid response to changing demands, or the ability to produce a wide range of customised services. Agility also more and more involves decisions to outsource, agreements with key suppliers, and novel partnering arrangements. Flexibility possibly will demand special strategies, such as implementing modular designs, sharing components, sharing manufacturing lines, or providing specialised training. Cost and cycle time reduction often engross Lean process management strategies. It is vital to utilise key measures for tracking all aspects of your overall process management.

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Category 7: Business Results

The Results Category provides a results focal point that encompasses your objective evaluation and your customers' evaluation of your organisation's products and services, your on the whole financial and market performance, your workforce results, your leadership system and social responsibility results, and results of all key processes and process enhancement activities. Through this focus, the Criteria's purposes - superior value of offerings as viewed by your customers and the marketplace; superior organisational performance as replicated in your operational, workforce, legal, ethical, and financial indicators; and organisational and personal learning - are maintained. Category 7 therefore provides "real-time" information (measures of progress) for evaluation and enhancement of processes, products, and services, in alignment with your overall organisational strategy.

Self Assessment

Fill in the blanks:

13. Tata Business Excellence Model is the foundation for conducting organisational assessments and for giving …… to applicants.
14. Tata Business Excellence Model has …… categories.
15. Category ……of Tata Business Excellence Model is the "brain centre" for the coalition of your organisation's operations with its strategic objectives.

7.5 Summary

- Strategic re-engineering focuses on designing the organization to create a dramatic improvement in performance.
- BPR must be "owned" throughout the organization, not driven by a group of outside consultants.
- Benchmarking is a continuous search for, and application of, significantly better practices that lead to superior competitive performance.
- For tracking down fineness or excellence, organizations follow the techniques which are Analyzing Cost time trade off and using project software.
- Organization has as its objective, optimizing a system where "Cost is a function of performance, time, and scope".
- Total project costs are constituted of direct costs, indirect costs, and penalty costs.
- For large projects, assistance of computer software is essential.
- The software creates a project schedule by superimposing project activities, with their precedence relationships and estimated duration time, on a time line.
- The TBEM philosophy has been moulded to deliver a amalgamation of strategic direction and concerted effort to maximise business performance.
- The Tata Business Excellency model spotlights on seven core aspects of operations: leadership, strategic planning, customer and market focus, measurement, analysis and knowledge management, human resource focus, process management and business results.

Notes

7.6 Keywords

Benchmarking: A continuous search for, and application of, significantly better practices that lead to superior competitive performance.

Leadership: It addresses how your senior leaders direct and sustain your organisation, setting organisational vision, values, and performance expectations.

Process Benchmarking: Benchmarking that focuses on improving specific critical processes and operations.

Process Management: It is the central point within the Criteria for your key work systems and work processes.

Total Project Costs: Costs that constitute direct costs, indirect costs, and penalty costs.

7.7 Review Questions

1. What are the important factors that need to be considered in the re-engineering effort?
2. Strategic re-engineering focuses on designing the organization to create a dramatic improvement in performance. Discuss.
3. Describe the correlation between core competencies and benchmarking.
4. Benchmarking is divided into several types on the basis of various aspects. What are those different types?
5. To what extent 'Analyzing Cost time trade off' helps organization in achieving excellence and effectiveness?
6. Time cost Trade-off procedures make use of some special terms. Explain those special terms.
7. How using project software assist organizations in pursuit for excellence?
8. Tata Business Excellence Model (TBEM) is the foundation for conducting organisational assessments. What are the additional significant roles of TBEM for strengthening competitiveness?
9. What are seven core aspects of operations that TBEM model spotlights on?
10. TBEM focuses on excellence. What are the performance excellence goals based on TBEM?

Answers: Self Assessment

1.	Strategic re-engineering	2.	prioritized
3.	feedback	4.	competencies
5.	Process	6.	Internal
7.	strategic	8.	four
9.	penalty	10.	scope
11.	time line	12.	Microsoft Office Project Professional 2003
13.	feedback	14.	seven
15.	4		

7.8 Further Readings

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Books

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

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

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Online links

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Notes

Unit 8: Supply Chain Management

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Objectives

After studying this unit, you will be able to:

- Explain the diverse aspects of purchasing;
- Recognize the significance of value engineering;
- Describe the different types and considerations of vendor relations;
- Discuss the concept of learning curve.

Introduction

The 1990s was a decade that brought in a quantum jump in many areas of management. One area of great change was in the area of business logistics, procurement and materials management. These disciplines went through several evolutionary stages starting with traditional procurement

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and materials management in the 1970s, which evolved into logistics management in the 1980s and then supply chain management in the 1990s. The reality is that few, if any, organizations have a department of supply chain management.

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.

8.1 Materials Management and the Supply Chain

The conceptual basis of the supply chain is not new. Supply chain management is involved with integrating three key flows across the boundaries of the companies: flow of information, product/materials, and funds between the different stages. Successful integration or coordination of these three flows produces improved efficiency and effectiveness for business organizations.

The concept of Supply Chain Management is based on two core ideas:

- The first is that practically every product that reaches an end user represents the cumulative effort of multiple organizations. These organizations are referred to collectively as the supply chain.
- The second idea is that organizations have to pay attention to what is happening outside their "four walls" and manage the entire chain of activities that ultimately delivers products to the final customer in order to maximize profits.

Figure 8.1: A Simplified View of Kalyani Breweries' Supply Chain

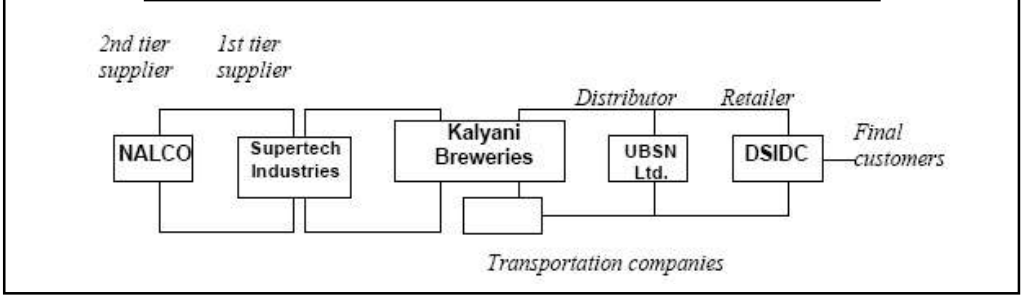

Figure above is a simplified version of the supply chain of Kalyani Breweries. When the typical customer goes to the store to buy beer, he probably does not consider all of the steps that occur for the product to reach him.

Example: Nalco extracts the aluminium ore and converts it into aluminium metal. The ingots are shipped to Supertech Industries at Bangalore, who converts the aluminium into cans. Supertech Industries supplies cans to Kalyani Breweries. In the supply chain Supertech Industries is a first-tier supplier to Kalyani Breweries because it supplies materials directly to the brewery and Nalco is a second-tier supplier. It is the supplier of a supplier.

The aluminium cans from Supertech Industries are combined with other raw materials, such as barley, hops, yeast, water and cartons, to produce the packaged beverage. Kalyani Breweries then sells the packaged beverage to UBSN Ltd., the distributor, who in turn sells the finished good to retailers like DSIDC. The logistic support is provided by transportation carriers, who carry the inputs and outputs from one place to the next along the supply chain.

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The flow of goods and information goes both ways which means that the participants in a supply chain are both customers and suppliers.

Example: Supertech Industries places an order (information) with Nalco, who in turn ships aluminium (product) to Supertech Industries. Supertech Industries is therefore a customer to Nalco and a supplier to Kalyani Breweries. If Kalyani Breweries returns empty pallets or containers to its first-tier suppliers, resulting in a flow of physical goods back up the supply chain, it becomes a supplier to Supertech Industries in addition to being its customer. This relationship reflects a single strand in the supply chain. There are many more participants in the supply chain than the ones shown above—Kalyani Breweries has hundreds of suppliers and the number of retailers is even higher.

Historically built on Procurement, Operations and Logistics foundations; Supply Chain Management goes beyond these traditional concepts. Physical flows involve the transformation, movement, storage of goods and materials and money and are the most visible part of the supply chain. But just as important are information flows. Information flows allow the various supply chain partners to coordinate their long-term plans, and to control the day-to-day flow of goods and material to the supply chain. The flow of products, services, and information go both up and down the chain.

Caution In order to make an effective supply chain, organizations that make up the supply chain are "linked" together through both physical and information flows.

Though "supply chain relationships aren't new", historically most participants in supply chains performed their activities independently of other firms in the chain. In contrast, supply chain management efforts involve individual firms taking steps to improve the flow of information between itself and its suppliers, improve and reduce variation in business processes and practices. In essence, the supply chain concept tries to make each participant in the chain more efficient.

For any supply chain, there is only one source of revenue: the customer. At DSIDC, a customer purchasing beer is the only one providing positive cash flow for the supply chain. All other cash flows are simply fund exchanges that occur within the supply chain, given that different stages have different owners. When DSIDC pays its supplier, it is taking a portion of the funds the customer provides and passing that money on to the supplier. All flows of information, product, or funds generate costs within the supply chain.

What is '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:

- Customers
- Retailers
- Wholesalers/Distributors
- Manufacturers
- Component/Raw material suppliers

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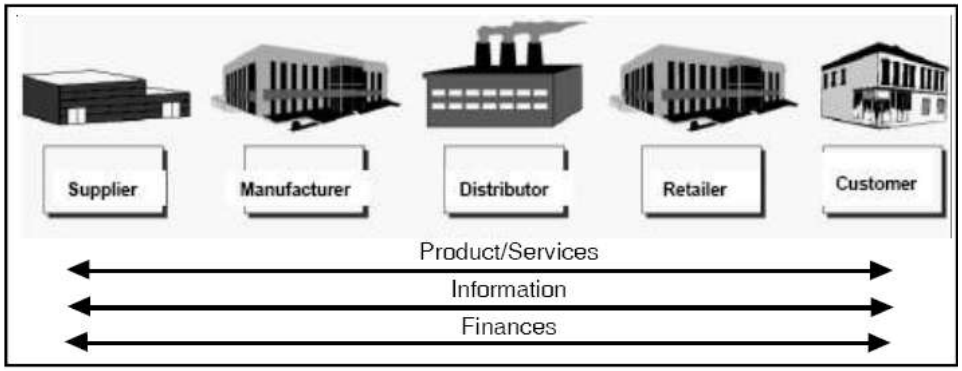
Figure 8.2: The Supply Chain



The concept of a supply chain is shown in Figure above. 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.

Notes 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.

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.

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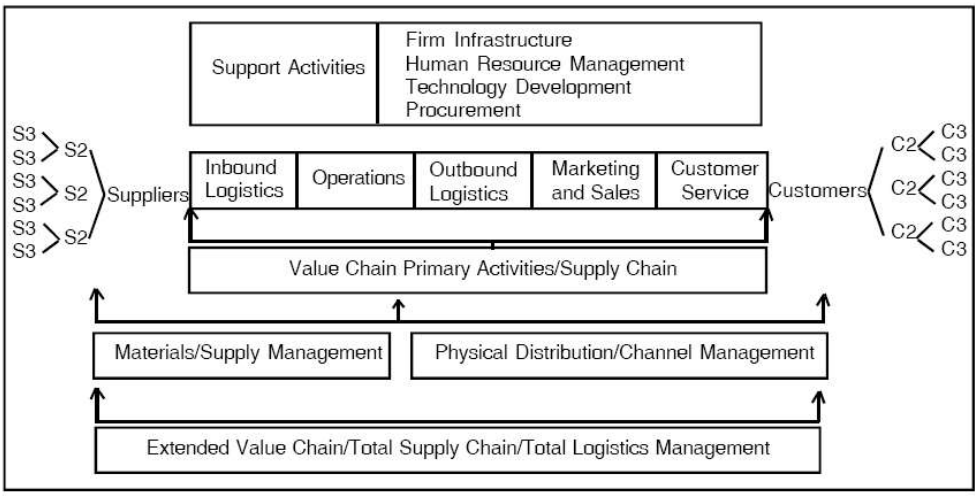
Figure below shows the supply chain as a network and also as a part of the value chain.

Figure 8.3: Supply Chain is 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.

Task 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?

Self Assessment

Fill in the blanks:

1. The flow of goods and information goes both ways which means that the participants in a supply chain are both customers and …… .
2. Supply chain is an integral part of the …… .
3. Supply chain activities begin with a …… and ends when a satisfied customer has paid for his or her purchase.

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8.2 Purchasing

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 small 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.

Did u know? 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.

8.2.1 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

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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.

Once the product is designed, purchasing has the following responsibilities:

- To determine the availability of parts and material.
- To collect up-to-date cost data that can be used to project the cost of producing the product in-house.
- To judge whether the specifications can be met from the current list of suppliers.
- 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.

8.2.2 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.

8.2.3 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 importances of product quality and delivery date requirements are reinforced in the mind of the supplier.

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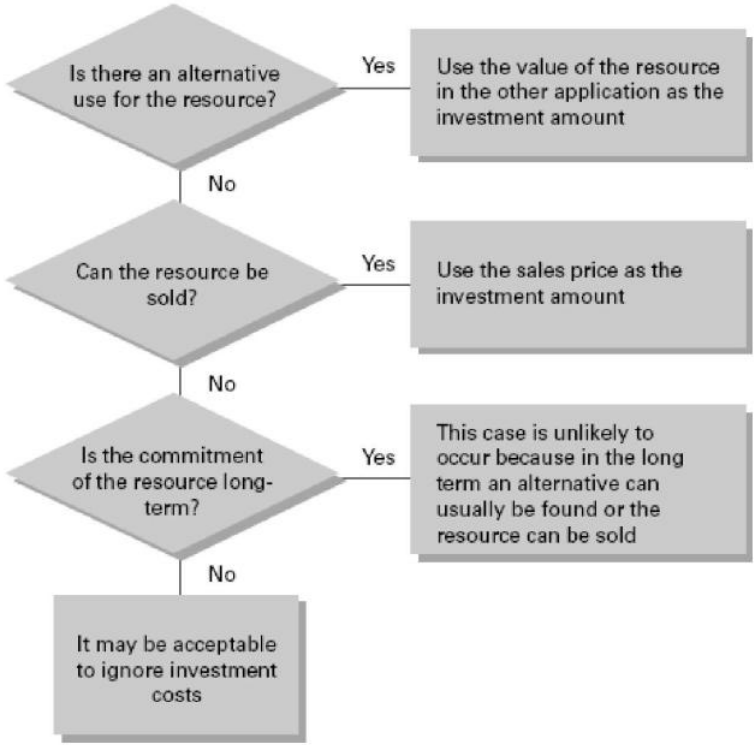
8.2.4 Evaluating the Make or Buy Decision

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?

Figure 8.4: Investment for Make or Buy Decision



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 above 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.

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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 weightages. 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.

8.2.5 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.

Caution 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.

8.2.6 Forward Buying

Purchasing retail inventory in quantities more than current demand, usually when manufacturers, or other suppliers, offer provisional discounts. When the promotion period expires, the retailer can then sell the left over inventory to consumers at regular prices, earning a bigger margin of profit. In several cases, an authorized dealer who receives a substantial discount might resell the merchandise to other retailers. Diverted units possibly will end up at "stores" or other less-than-selective retailers to which manufacturers do not sell directly. Those retailers can sell to the public at a discount the authorized dealer is not permissible to offer. Retailers who use aggressive

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forward buying and diverting practices may make as much profit all the way through these buying practices as they create through non-promotional sales to consumers. Manufacturers offer discounts to retailers presumptuous the retailer will pass the savings on to consumers. The discounts also can speedily move a large amount of inventory when the manufacturer needs to reduce stock. As more retailers make use of the forward buying strategy, manufacturers such as Procter & Gamble are switching to every day low pricing (EDLP) strategies in its place.

Self Assessment

Fill in the blanks:

4. Purchases represent about …… percent of the cost of the finished product.
5. Three criteria most often considered by firms selecting new suppliers are price, quality, and …… .
6 A …… decision should be viewed as an investment decision.

8.3 Value Analysis/Value Engineering

What provides value to the product? A way to consider the customer's view in designing products is by analyzing the value they see in the end product. It is important that the value be designed into products.

Value Engineering is an organized creative technique directed at analyzing the functions of a product, service or system with the purpose of achieving the required functions at the lowest overall cost consistent with all the requirements, which comprise its value, such as performance, reliability, maintainability, appearance, etc.

Value, in general, is defined as the ratio of the function and cost. It reflects what the product, service or system accomplishes and at what cost. Thus:

Value = Function/Cost

Where, 'Function' is expressed as units of performance, and

'Cost' is expressed as a monetary unit.

Value engineering is used as a generic term and generally includes value analysis.

Did u know? **What is the purpose of value analysis/Value Engineering?**

The purpose of both value analysis (VA) and value engineering (VE) is to simplify products and processes.

VA specifically deals with products already in production and is a cost reduction technique. It is used to analyze product specifications as shown in production documents to achieve similar or better performance at a lower cost while maintaining all functional requirements defined by the customer. Value engineering is performed before the production stage, and is considered a cost avoidance method.

Value Engineering starts with the classification and identification of a product, service or system. The functions of the product, service or system are identified. Each function is evaluated and compared. The process involved in value engineering is as follows:

Step 1: Identify each of the functions of the product or service and list them down.

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Step 2: Give a weight to the importance of each function, such that the total of the weights comes to '1'. Rearrange the functions on the basis of their importance.

Step 3: Identify each of the components in the product or service and list its functions.

Step 4: The functions of the components have to be related to the product and the functions of the product. Each component will have to be given a weight to show how it contributes to the function of the product or service. There may be some components that have more than one function. This should be taken into account.

Step 5: Identify the cost of each component and convert it to a weight corresponding to the total cost so that the total of the weights does not exceed '1', just as it was done in step 2.

Step 6: Compare the weights of the functions with the weights of the cost of each of the components.

Step 7: Identify those components where the ratio of Function/Cost is low.

The components with a low ratio of Function/Cost are identified for further examination. The VA/VE analysis approach involves taking these identified components and brainstorming with such questions as:

- Does the item have any design features that are not necessary?
- Can two or more parts be combined into one?
- How can we cut down the weight?
- Are there nonstandard parts that can be eliminated?

Figure 8.5: Value Engineering Effort on a Sub-assembly

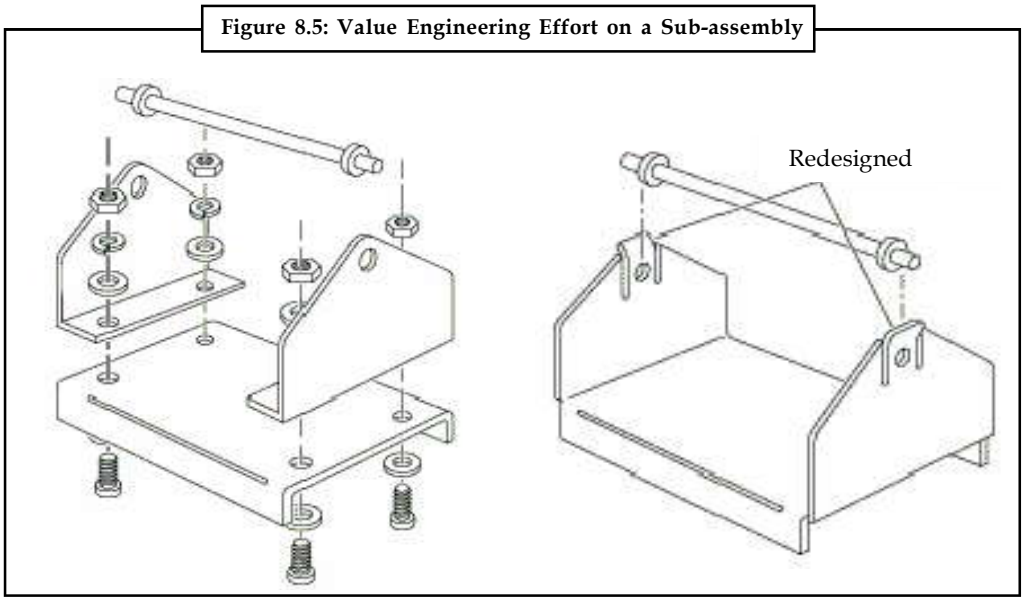

Figure above shows a sub-assembly that was used in Escorts in the railway Equipment division. The original sub-assembly had four major components that were joined together using fasteners. After redesign, using value engineering, it was reduced to just two components that were fitted together using a push and snap mechanism. This exercise reduced the cost of the sub-assembly by nearly 30 per cent. It reduced stocking of 20 components, which were required for fastening.

VA/VE is a continuous process. Typically, there is a looping back and forth between VA and VE for a given product. This occurs because new materials, processes, etc., require the application of VA techniques to products that have previously undergone VE.

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Self Assessment

Fill in the blanks:

7. Value engineering is used as a ……term and generally includes value analysis.
8. Value engineering is performed before the ……. stage, and is considered a cost avoidance method.
9. Value Engineering starts with the ……and identification of a product, service or system.

8.4 Vendor Relationships

Supply Chain relationships have their historical origins in the Japanese keiretsu structure. Keiretsu is an example of a group of firms using supply chain strategies to achieve a common purpose. Suppliers, with some degree of vertical ownership with the manufacturer, enjoy high volume and long-term supply contracts. The keiretsu did not need to have a typical cross-organizational structure because of its traditional relationship. However, the keiretsu offers an insight of how suppliers enjoy close ties with manufacturers. Firms establish ties with each other on the basis of a mutual belief - exchange personnel; share technology and information; in effect sharing both the risk and rewards of the relationship.

The supplier-buyer relationships have seen a paradigm change in the transition from Materials Management to Supply Chain Management. The supply chain structure has been sculpted on the Japanese keiretsu. But, Japan has a culture where the keiretsu is possible. How does this reflect on SCM in general? Before we discuss this question, the question we need to focus on first is: What are the different types of supplier-buyer relationships?

There are three types of relationships:

- Transactional
- Collaborative, and
- Alliance

These are described in greater detail below:

8.4.1 Transactional Relationships

The most common and most basic type of relationship is "transactional." Virtually, all buying firms will have transactional relationships.

Example: Directorate General of Supplies and Disposal (DGS&D) is a government organization under the Ministry of Commerce. The organization provides procurement services to Central & State Government Departments/Organizations, Public Sector Undertakings and Autonomous Bodies, by placing Rate Contracts for common user items and contracts against their ad-hoc demands. This is a typical transactional relationship. This type of relationship simply means that neither party is especially concerned with the well-being of the other. It is neither good nor bad. Transactional purchases lend themselves to e-procurement and, in some cases, reverse auctions.

Characteristics of Transactional Relationships

Transactional relationships have several characteristics. To start with, the relationship is formal. It is characterized by an absence of concern by both the buyer and the seller about the other

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party's well-being. They see the relationship as a zero sum game i.e. what one party wins, the other loses.

The transactions are also seen as a series of independent deals. Each transaction is entered into on its own merits. Therefore, there is limited contact between the buyer and the seller. There is also little or no basis for collaboration and learning from each other.

Basic data relating to technical data, special features, costs, and forecasts, etc. are not shared. As these are arm's-length transactions, the focus is on price.

Example: DGS&D uses open tenders for each transaction. Both the buyer and the seller try to get the best price. There is no openness in such a relationship.

If there is any cost analysis, it precedes the procurement transaction. It is done separately by the buyer and the seller, and they do not share data. Since the prices are established by market forces, neither buyer nor supplier will rush to the other's assistance in bad times or when problems arise.

Most of the procurement effort is in establishing rules, regulations, and procedures governing such transactions. Therefore, little purchasing time and energy are required to establish prices, as market forces establish prices in transactional relationships.

Advantages of Transactional Relationships

Though transactional relationships are formal and inflexible, in certain cases, they are advantageous to the firm. The major advantage is that transactional purchases lend themselves to e-procurement and, in some cases, reverse auctions.

In the case of conventional procurement transactions, there is relatively less purchasing time and effort required to establish price, as these are established primarily by market forces. With the vast majority of transactional procurements, judgment and managerial expertise are seldom required. This is advantageous for commodity items as little purchasing time and efforts are required to establish price. The transactions are mechanical and hence, lower skill levels of procurement personnel are required.

Disadvantages of Transactional Relationships

The disadvantages of such relationships stem from the fact that the supplier recognizes the transactional and price nature of the relationship and is not motivated to invest time and energy in the development of the potential buyer's products.

Transactional procurements tend to provide for products where quality is only as good as required. It often results in more problems. As there are many unknowns about the seller's capabilities, considerable investment in expediting and the monitoring of incoming quality is required to ensure timely delivery of the right quality. There is little incentive and opportunity to improve quality and delivery in this type of relationship.

Transactional relationships are generally inflexible. Very often, flexibility may be required in supplier-buyer relationships due to changing technology or changing market conditions. It is generally not possible in transactional purchases.

Transactional suppliers tend to provide the minimum service required. There is little communication between the buyer and the seller. Transactional suppliers have little to lose from a dissatisfied customer, if they can meet with the contractual requirements of the buyers.

The risks and uncertainties present with transactional relationships reduce the likelihood of investments in R&D and training as well as the procurement of new, more efficient equipment focused on the customer firm's needs.

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8.4.2 Collaborative Relationships

The awareness of the interdependence and necessity of cooperation is the key difference between collaborative relationships and transactional ones. Organizations perform a series of value-adding activities working together by recognizing the interdependency and need of cooperation, to provide benefits to both parties. These include cost reduction, improved quality, reduced time to market, and the leveraging of supplier technology.

The three most important factors required for a successful collaborative relationship between a buyer and a supplier are:

1. Two-way communication,
2. Responsiveness to supply management's needs, and
3. Clear product specifications.

Collaboration happens because both parties are aware that money enters their supply chain (or supply network) only if the chain's end products are cost competitive. When collaborative relations replace the market forces employed by transactional procurement, there is overall improvement in many areas. There is controlled competition, benchmarking, and advanced supply management pricing practices. The end results are lower total costs, higher quality, reduced time to market, and reduced risk of supply disruptions.

Example: Collaborative relationship is between Tata Motors and Mahindra Ugine. Tata Motors has a large requirement of alloy steel billets for its Forge Division at Jamshedpur. Of the large number of possible suppliers, Tata Motors chose Mahindra Ugine as one of the three suppliers with whom they negotiate prices and quantities for their different requirements, based on quality, R&D, timeliness of supply, process capability, and after sales service ability. The criterion was not price, but the value delivery of the seller. Based on their past performance, Tata Motors would reward its strategic partners with a larger proportion of the total orders. This acts as an incentive to perform better than the others.

As both parties recognize their relationship is long-term, their interdependence and the need for cooperation, this is reflected in their continual effort to mutually work together towards cost reduction and improved quality.

Example: Mahindra Ugine offers new alloy developments to Tata Motors to develop components with improved specifications and lower costs. Such acts extend the relationship between the two parties.

Advantages of Collaborative Relationships

Continuous improvement is far easier to implement and manage with recognized interdependence and cooperation. The end objective with continuous improvement is a reduction in total costs.

Improved quality and timeliness also result. The likelihood of supply disruptions is greatly reduced.

With a high level of certainty and continuity of demand, sellers are prone to explore improving processes and adopting technical innovations. They are also willing to work with their buyers on new ideas. This often results in cost reduction for both the buying and supplying organizations.

Cost reductions resulting from value engineering and value analysis (VENA) are much more likely with collaborative relationships. Suppliers are more likely to take the initiative to reduce

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costs through VENA when they are involved in long-term relations. As was discussed earlier, Maruti Udyog were able to reduce component costs on the Alto alone, from 2001 to 2005, by 29 percent.

Long-term performance agreements are an incentive to suppliers to reduce their costs. The extended learning curve effects with both production and services allowing collaborative and alliance suppliers to reduce their costs and share these savings with customers.

Disadvantages of Collaborative Relationships

The major disadvantage of collaborative relationships is the amount of human resources and thought that is required to develop and manage such relationships.

Caution It takes a lot of time and energy, judgment and managerial expertise to make collaborative relationships successful.

8.4.3 Supply Alliances

Supply alliances go one step further. These relationships are based when there is institutional trust between the buyer and the seller. A high level of recognized interdependence and commitment is present in such relationships. There is a visible atmosphere of cooperation. The buyer and the seller address potential conflicts and resolve them openly. When problems occur, the focus is a search for the root cause, not to assign blame.

Alliances are not legal entities, but mutually beneficial and open relationships wherein the needs of both, the buyer and the seller, are satisfied. They are similar to collaborative relationships, but stronger. But, these are difficult to develop, because supply alliances only work when the buyer and the seller are able to develop and manage institutional trust.

Properly configured, supply alliances reap incredible benefits. Sellers are willing to invest in customized machinery, tools, information systems, delivery processes, etc., due to the long-term relationship with the buyer. This gives the buyer faster throughput and allows for product differentiation. It also leads to improved overall quality as the product integrity increases.

Sellers also accumulate specific know-how of the buyers market and requirements by working together. This accumulated specialized information and language allows both the buyer and the seller to communicate and coordinate effectively with each other. They are both less likely to have communication breakdowns that result in errors. The final result is higher quality, faster development times, and lower costs for the customer.

Notes The focus of most supplier alliances is achieving the simultaneous objectives of continuous improvements along with squeezing cost out. Negotiations and re-negotiations occur in a win-win manner.

Example: Supply alliance in India is between General Motors (GM) and H.P. Pelzer (India) Ltd. Alliances are very difficult to establish; however, the Pelzer alliance was made possible because a similar relationship existed between GM, Germany, and H.P. Pelzer, Germany. For their plant at Hallol, GM developed all their automotive insulation parts from Pelzer. They chose one supplier from the many who could make their parts. GM and Pelzer actively

participated together in process control and process improvement. Pelzer was connected through an information system with GM. Both parties used cross-functional teams that would meet from time to time. In return, Pelzer willingly invested in redesigning the insulative package to Indian conditions.

An alliance is a living system that progressively evolves with the objective of creating new benefits for both parties. The alliance partners share a vision of the future in the area of the interface. Ethics take precedence over expediency. The relationship is adaptable in the face of changing economics, competition, technology, and environmental issues.

In most supply alliances, the use of supplier certification is common. By improving the process, the manufacturing quality is raised, which reduces requirements to inspect for errors. The result is improved quality at lower total cost.

Executive level commitment and alliance champions protect the alliance from incursions by non-believers.

Advantages of Supply Alliances

The primary benefits of supply alliances include lower total costs. Synergies are created in alliances that cannot happen in transactional or even collaborative relationships. The synergies result in reductions of direct and indirect costs associated with labour, machinery, materials, and overhead. Alliance customers are the least likely to experience quality problems or supply disruptions.

Buyers enjoy the benefits of Early Supplier Involvement (ESI) in the development of new components. Reducing the time to design, develop, and distribute products and services becomes a competitive advantage and leads to improved market share and better profit margins.

Openness and institutional trust enhance the inflow of technology from alliance partners that leads to many successful new products. For example, in the case of GM and Pelzer, Pelzer invested in R&D to bring down the cost of the entire insulative package for GM. They were able to reduce their costs by nearly 20 percent in a period of two years and passed on the cost benefit on to GM so that their product could be priced competitively. The result was higher volumes for Corsa, which benefited both the alliance partners.

Alliance relationships help cushion bad times. Both customers and suppliers who value each other, based on long-term relations and respect, are more likely to come to each other's aid during times of adversity.

Disadvantages of Supply Alliances

The major disadvantage of alliance relationships is the amount of human resources and thought that is required to develop and manage such relationships. Alliances are a very resource-intense approach to supply management.

The focus on relationship management requires that all elements of relationship management, including trust building, communications, joint efforts, and planning and fostering interdependency, will be increasingly studied and managed to achieve competitive advantage in the relationship.

It takes cross-functional teams, early supplier involvement, target costing, improved communications through techniques such as co-location of supplier engineers, and a constant contact with the supplier. This requires a lot of time and energy, judgment and a very high level of managerial expertise to make collaborative relationships successful.

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8.4.4 Supplier Relationship Management (SRM) Focus

The SRM macro process aims to arrange for and manage supply sources for various goods and services. Supplier relationship management is a comprehensive approach to managing an enterprise's interactions with suppliers. Its objective is to streamline and make more effective the processes between an enterprise and its suppliers. This is in a sense similar to customer relationship management (CRM) which streamlines and makes more effective the processes between the firm and its customers.

SRM reflects the need to integrate the entire supply chain – and to do so in a way that preserves flexibility, opens its enterprise infrastructure to the inventions, expertise and networks of others, and lets them shed the bits of the supply chain that can be better run by partners. SRM practices create a common frame of reference to enable effective communication between an enterprise and suppliers who may use quite different business practices and terminology. SRM processes include the evaluation and selection of suppliers, negotiation of supply terms, communication regarding new product and orders with suppliers and integration with the expertise of others.

All the three macro processes are aimed at serving the same customer. However, integration of the systems is to a large degree dependent on the organizational structure of the firm. In many firms, marketing is in charge of the CRM macro process, manufacturing handles the ISCM macro process and purchasing oversees the SRM. Integration between the three macro processes is crucial for successful supply chain. Use of databases, communication systems, and foremost advanced computer software are crucial for the development of a modern cost-effective integrated SCM.

The collaboration and coordination costs of the supply chain increase with the speed of change in the marketplace. A proactive approach to manage customer demands is necessary to stay competitive. This requires flexibility in the supply chain while cutting hidden costs and reducing transaction costs.

For example, Speeding up sharing of information through electronic means, can help partners lower production cycle times and inventory can be viewed on a real-time basis so forecasting errors can be reduced. This will contribute to the objectives of satisfied customers and low costs.

Self Assessment

Fill in the blanks:

10. There are three types of vendor relationships which are Transactional, Collaborative, and …… .
11. The three factors required for a successful collaborative relationship are Two-way communication, Responsiveness to supply management's needs, and…… .
12. The supplier-buyer relationships have seen a paradigm change in the transition from Materials Management to …… Management.

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

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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 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

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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.

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

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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.
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, non-profits, 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

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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

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 non-profits, 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 non-profits 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 fund-raising 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

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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.

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 workplace 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.

8.5 Learning Curves

A learning curve is a line displaying the relationship between unit production time and cumulative number of units produced. The theory of learning curves is based on three assumptions:

- The time taken to complete a given task or activity will go down, each time the task or activity is undertaken,

Notes

- The unit time will decrease at a decreasing rate, and
- The reduction in time will follow a predictable pattern.

Each of these assumptions has been found to hold true in the aircraft industry. Though this technique was started by the aviation industry, it has been found applicable in most production applications. The learning percent is usually determined by statistical analysis of actual cost data for similar products.

Examples are:

1. Aerospace 85%
2. Shipbuilding 80-85%
3. Complex machine tools for new models 75-85%
4. Repetitive electronics manufacturing 90-95%
5. Repetitive machining or punch-press operations 90-95%
6. Repetitive electrical operations 75-85%
7. Repetitive welding operations 90%
8. Raw materials 93-96%
9. Purchased parts 85-88%

There are several models of learning curves in use in business and industry; the most common form of the relationship between inputs per product is a log-linear model in the form of the function:

$$y = ax^{-b}$$

Where: y = input cost for the xth unit

x = cumulative number of units produced

a = input cost for the first unit

b = progress rate

The log-linear model states that the improvement in productivity is constant (i.e., it has a constant slope) as output increases. There are two basic forms of the log-linear model—the average cost function and the unit cost function.

Average Cost Model

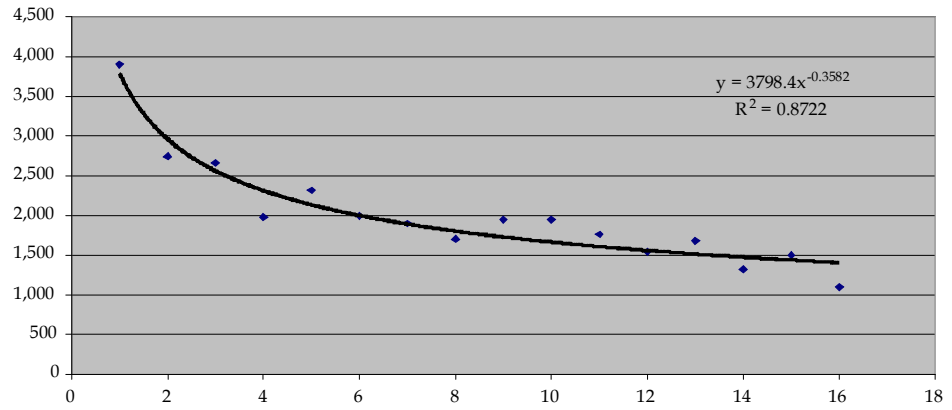
The average cost model is used more than the unit cost model. It specifies the relationship between the cumulative average cost per unit and cumulative production. The relationship indicates that cumulative cost per unit will decrease by a constant percentage as the cumulative production volume doubles.

Unit Cost Model

The unit cost model is expressed in terms of the specific cost of producing the 'x'th unit. The unit cost formula specifies that the individual cost per unit will decrease by a constant percentage as cumulative production doubles. A typical graph is shown in Figure 8.6.

Notes

Figure 8.6: Individual Unit Time Model



Example: Piper Aircraft Corporation presented a proposal to Hindustan Aeronautics Limited (HAL) for the manufacture of executive aircraft in India. In their proposal, they calculated the direct man-hours required for the assembly of the aircraft in India. The total standard hours required to assemble the aircraft at Piper Assembly Plant at Vero Beach, USA, was 9409 hours.

This was translated into a learning curve to estimate the time. The time required at 55 per cent efficiency and 83 per cent learning used by Piper is shown in Table below.

Table 8.1: Learning Curve for Executive Aircraft Assembly: 55% Efficiency; 83% Learning Curve

Unit No.	India Direct Hours	Piper Direct Hours	Total* Direct Hours
4	17956.4	17467.7	35424.1
5	14573.1	17335.8	31908.8
6	13489.6	17208.8	30698.4
7	12818.3	17086.5	29904.8
8	12334.8	16968.6	29303.4
9	11959.0	16854.8	28813.8
10	11653.1	16744.8	28397.8
11	11395.9	16638.4	28034.3
12	11174.7	16535.4	27710.1
13	10981.1	16435.7	27416.8
14	10809.2	16339.0	27148.2
15	10655.0	16245.1	26900.1
16	10515.2	16154.0	26669.3
17	10387.7	16065.5	26453.2
18	10270.4	15979.4	26249.8
19	10162.0	15895.7	26057.7
20	10061.3	15814.2	25875.5
Cum.	201196.8/20	281769.4/20	482966.1/20
Average	10059.8	14088.5	24148.3

* Based on assembly of 4 Aircraft per month.

Notes

The table shows that the learning curve is exponential. It also shows a difference in the reduction in time between Piper Aircraft Corporation and HAL. The reduction in time at HAL between the 4th unit and the 20th unit is nearly 7900 direct hours and in the case of Piper, it is 1700 hours.

The reason for this difference is that Piper already had programs where it was supplying CKD packs to Columbia, Brazil, Argentina, Poland and Chile. Therefore, Piper starts learning from a different point on the learning curve than would HAL, for whom the product is completely new.

The learning curve will vary on different programs. A table of percentages for each type of program can be developed by taking the ratio of the average hours for the total program to the average hours for the first half of the total units.

Example: The average hours for 200 units are 80 hours, and the average hours for the first 100 units were 100 hours each. Thus, 80/100 equals 80 per cent. This is an 80 per cent curve.

Various curves are classified as 80 per cent, 86 per cent, 90 per cent, etc., curves. If an 80 per cent curve were plotted on arithmetic paper, we would expect a different-shaped curve for each project. If it is plotted on log-log paper, all curves will be straight lines. Tables for the various percentage curves can be developed and so accurate figures can be calculated without using the more complicated mathematical formulas.

Self Assessment

Fill in the blanks:

13. A learning curve is a line displaying the relationship between unit production time and …… of units produced.
14. The …… model is expressed in terms of the specific cost of producing the 'x'th unit.
15. The log-linear model states that the improvement in productivity is …… as output increases.

8.6 Summary

- '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.
- 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.
- Purchases represent about 55 percent of the cost of the finished product and purchasing is a major constituent of the supply chain.
- A make or buy decision should be viewed as an investment decision and should take into account considerations other than the economic factors like Technology, Quality, and Timely Delivery.
- Value Engineering is an organized creative technique directed at analyzing the functions of a product, service or system with the purpose of achieving the required functions at the lowest overall cost.
- Value Engineering starts with the classification and identification of a product, service or system.

Notes

- There are three types of vendor relationships which are Transactional, Collaborative, and Alliance.
- The collaboration and coordination costs of the supply chain increase with the speed of change in the marketplace.
- A learning curve is a line displaying the relationship between unit production time and cumulative number of units produced.
- The learning curve will vary on different programs.

8.7 Keywords

Learning Curve: It is a line displaying the relationship between unit production time and cumulative number of units produced.

Supply Chain: It consists of organizations that are connected through three key flows across their boundaries—flow of information, product/materials, and funds between the different stages.

'Supply Chain Management: It relates to the entirety of integration-oriented skills required for providing competitive advantage to the organization, skills that are the basis for successful supply chains.

Unit Cost Model: The model which is expressed in terms of the specific cost of producing the 'x'th unit.

Value: It is the ratio of the function and cost which reflects what the product, service or system accomplishes and at what cost.

8.8 Review Questions

1. Explain the concept of supply chain. What is its scope? Explain what you understand by the term 'supply chain integration'.
2. 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.
3. Can a supply chain be both efficient and responsive? Why or why not?
4. A firm improves its forecast accuracy using better market intelligence? What impact will this have on supply chain and profitability? Why?
5. What are the relevant questions that management should consider in deciding the make or buy decisions?
6. How can the performance of supply-chain be measured?
7. What are the different types of buyer-seller relationships? Describe when would you choose to have a supply alliance and why?
8. How would you decide whether to enter into a partnership or alliance with another firm?
9 Explain the steps in the process of value engineering?
10. What are the assumptions on which theory of learning curve is based?

Notes

Answers: Self Assessment

1. suppliers
2. value chain
3. customer order
4. 55
5. delivery
6. make or buy
7. generic
8. production
9. classification
10. Alliance
11. Clear product specifications
12. Supply Chain
13. cumulative number
14. unit cost
15. constant

8.9 Further Readings

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lcm.csa.iisc.ernet.in/scm/supply_chain_intro.html

tutor2u.net/business/production/just-in-time.html

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Unit 9: Inventory Model and Safety Stocks

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Objectives

After studying this unit, you will be able to:

- Recognize the functions and costs of Inventory;
- Describe the inventory control by classification system;
- Explain the concept of Economic Order Quantity (EOQ).

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. 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.

Notes

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 as 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 setups. 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 setups, or protect employment levels by minimizing the cost of changing the rate of production.

Caution It is required 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.

Notes

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.

Self Assessment

Fill in the blanks:

1. The cost of increasing production and employment level involves employment and training, additional staff and service activities, added shifts, and …… costs.
2. If the demand for the product is known ……, it may be possible to produce the product to exactly meet the demand.
3. Inventories permit production planning for smoother flow and lower cost operation through …… production.

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, and
2. How large the order should be.
3. "When" and "how many to deliver".

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:

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 favour 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. The general break down for inventory holding costs has been shown in table.

Table 9.1: Fixed and Variable Holding Costs

Fixed costs	Variable costs
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

Notes

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. The general breakdown between fixed and variable ordering costs is as follows:

Table 9.2: 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.

Set up (or production change) Costs: 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.

Caution It must be remembered that inventory is costly and large amounts of stocks are generally undesirable.

Notes

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.

Self Assessment

Fill in the blanks:

4. The heart of …… decisions lies in the identification of inventory costs and optimizing the costs relative to the operations of the organization.
5. The costs that are incurred as result of running out of stock are known as …… costs.
6. Ordering costs have two components in which one component is relatively …… and another component will …… .

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.

9.3.1 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

Notes

usage, while the remaining 80 percent of the items typically account for remaining 20 per cent 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 per cent, 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 per cent 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 per cent of the items are classified as 'B' items. These deserve less attention than 'A' items. Finally, the last 50 per cent 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 9.3: 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	21.96	21.96	'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			

Example: The ABC Analysis shows that in the 16 items in the BOM, the first 20 per cent have a rupee usage of 60.35 per cent, the next thirty per cent have a rupee usage of 25.77 per cent, and the last 50 per cent have a rupee usage value of only 13.88 per cent. 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.

Notes

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.

Caution 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.

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,

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, re-establish supply lead times, and the reorder points. Cost savings might result in changes in EOQ, but they may not be significant.

9.3.2 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 9.4.

Notes

Table 9.4: 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.

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.

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.

V' stands for vital, 'E' for essential, 'D' for desirable. This classification is generally applied for spare parts to be stocked for repairs of machines and equipments based on the criticality of the spare parts. The stocking policy is foundational on the criticality of the items. The vital spare parts are known as capital or insurance spares. The inventory policy is to maintain at least one number of the vital spare irrespective of the long lead-time necessary for procurement. Essential spare parts are those whose non-availability may not harmfully affect production. Such spare parts may be obtainable from many sources within the country and the procurement lead time many not be long. Hence, a low inventory of essential spare parts is detained. The desirable spare parts are those, which, if not presented, can be manufactured by the maintenance department or may be procured from local suppliers and therefore no stock is held usually.

Did u know? **What is HML classification?**

The HML (High, Medium and Low) 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.

Notes

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 and scheduling' decisions.

Self Assessment

Fill in the blanks:

7. The ABC classification is based on focusing efforts where the …… is highest
8. The VED Classification is based on the …… of the inventory item.
9. In VED Classification 'V' stands for …… .

9.4 Inventory Control

Recent industry reports show that inventory costs as a per cent 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.

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.

9.4.1 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.

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.

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.

Notes

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.

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.

Notes **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 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.

9.4.2 Economic Order Quantity (EOQ)/Optimal Order Quantity

The optimum quantity (lot size) using a tabular approach is called the Economic Order Quantity (EOQ). The order quantity at which the total cost is minimum (Q*) can mathematically be expressed as:

$$\text{As } TVC(Q) = DS/Q + HQ/2 \qquad ...(1)$$

Differentiating the Equation

$$dTVC(Q)/dQ = - C R/Q^2 + H/2 = 0$$

Notes

$$Q = Q^* \sqrt{(2DS/H)} = \sqrt{(2DS/FP)} = EOQ \quad ...(2)$$

This equation is known as the EOQ formula. From this formula, the optimal time between orders can be derived.

$$T^{Q^*} = D/Q = D/\sqrt{(2DS/H)} = \sqrt{(DH/2S)}$$

The Minimum Total Annual Cost (TC) of holding inventory is given by the formula:

TVC(Q) = DS/Q + HQ/2

If Q = Q*, then:

TVC(Q*) = DS/Q* + HQ*/2

= DSQ*/Q*Q* + HQ*/2

= DSQ */(2DS/H) + HQ*/2)

= HQ*/2 + HQ*/2

TVC(Q*) = HQ* ...(3)

In the above discussion, we considered that lead time is zero. However, if lead time is constant, the above results can also be used without any modification.

If lead time is say constant ('ab' = 'cd' = 'ef') and equal to 'L', then during lead time, the consumption is L*D units. This means the order will have to be released for quantity Q*, 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. It can be mathematically expressed by the equation:

Reorder Level = **RB = LD** ...(4)

Where, 'L' is given in years and 'D' is the annual demand.

Let us work out an example to understand the EOQ Model and all that has been said earlier in this section on fixed order quantity policies:

Example: A company, ABC Ltd., 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
'P' = Unit purchase cost	= ₹ 40.00
'S' = Ordering Cost	= ₹ 5400.00
'F' = Holding Cost	= 40%

Using the Economic Order Equation:

$$Q^* = \sqrt{(2DS/H)} = \sqrt{2DS/FP} = EOQ$$

$$= \sqrt{(2*5400*1200)/(0.40*40)}$$

Notes

Minimum Total Annual Cost: TVC(Q*) = FPQ*

= 900*0.40*40

= ₹ 14,400.00

The Total Annual Cost under the present system = TVC(Q) = DS/Q + HQ/2

= ₹ (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: RB = 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.

Notes **EOQ Model with 'Lead Time'**

In the discussion, we considered that lead time is zero. However, if lead time is constant, the results can be used without any modification.

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 QEOQ. 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. It can be mathematically expressed by the equation:

Reorder Level = Ro = L*D

Let us work out an example to understand the EOQ Model and all that has been said earlier in this section on fixed order quantity policies:

Example: 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 per cent, 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:

QEOQ = √ (2*A*D /r*v) = √ (2 *5400*1200)/(0.40*40) = 900 units.

Minimum Total Annual Cost (TC) = √ 2*A*D*r*v

Contd...

Notes

= √ 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 = Ro = 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.

9.4.3 EOQ Model with Demand and Delivery Uncertainty

If you have both demand and delivery (lead time) uncertainty, you must use a convolution formula (Bowersox 2010) to calculate the safety stock level.

Standard Deviation of Combined Probabilities

σc = Square Root of [(L * σd^2) + (d^2 * σl^2)], where

- L = Lead time (in days)
- d = the average daily demand
- σd = the standard deviation of daily demand (demand variation)
- σd = STDEV (daily demand times) when using Excel
- σl = Standard Deviation of lead time = STDEV (lead times)

Reorder Point = R = (d * L) + (NORMSINV(p) * σc)

Reorder Point = R = (d * L) + (NORMSINV(p) * Square Root of [(L * σd^2) + (d^2 * σl^2)]

Type I and Type II Error

A statistical hypothesis test is a method of making statistical decisions using experimental data. There are two types of errors:

1. Hypothesis is rejected when it is true.
2. Hypothesis is not rejected when it is false.

(1) is called Type 1 error (a), (2) is called Type 2 error (b). When a = 0.10 it means that true hypothesis will be accepted in 90 out of 100 occasions. Thus, there is a risk of rejecting a true hypothesis in 10 out of every 100 occasions. To reduce the risk, use a = 0.01 which implies that we are prepared to take a 1% risk i.e., the probability of rejecting a true hypothesis is 1%. It is also possible that in hypothesis testing, we may commit Type 2 error (b) i.e., accepting a null hypothesis which is false.

Did u know? The only way to reduce Type 1 and Type 2 error is by increasing the sample size.

Example of Type 1 and Type 2 Error

Type 1 and Type 2 error is presented as follows. Suppose a marketing company has 2 distributors (retailers) with varying capabilities. On the basis of capabilities, the company has grouped them

Notes

into two categories (1) Competent retailer (2) Incompetent retailer. Thus R1 is a competent retailer and R2 is an incompetent retailer. The firm wishes to award a performance bonus (as a part of trade promotion) to encourage good retailership. Assume that two actions A1 and A2 would represent whether the bonus or trade incentive is given and not given. This is shown as follows:

Action	(R1) Competent retailer	(R2) Incompetent retailer
A 1 performance bonus is awarded	Correct decision	Incorrect decision error (β)
A 2 performance bonus is not awarded	Incorrect decision error (α)	Correct decision

When the firm has failed to reward a competent retailer, it has committed type-2 error. On the other hand, when it was rewarded to an incompetent retailer, it has committed type-1 Error.

9.4.4 The Economic Batch Quantity (EBQ)

The Economic Batch Quantity model, or production lot-size model, is alike to the EOQ model in that we are attempting to work out an optimum for the batch quantity we have to produce.

Economic batch quantity (EBQ), as well called "optimal batch quantity" or economic production quantity, is a measure employed to determine the quantity of units that can be produced at minimum average costs in a specified batch or production run.

Economic Production Quantity model (also recognized as the EPQ model) is an extension of the Economic Order Quantity model. The Economic Batch Quantity model, or else production lot-size model, is alike to the EOQ model in that we are attempting to calculate an optimum for the batch quantity we have to produce.

In working with this EBQ model, we also put together use of a number of assumptions.

These principal assumptions are:

- The demand (D) is identified and constant within a certain period of time
- The unit cost of the inventory item (U) is stable
- The annual holding-cost per unit (C_h) is stable
- The setup-cost per batch (C) is stable
- The production time (t_p) is known and stable
- We are dealing with single kind of product
- There is no interface with other products
- The aspect of time does not play a role, just the setup time does
- The setup cost is stable and does not act upon the batch quantity.

Task Hindustan Lever is a manufacturer of the Surf detergent powder. A 100-g pack of its detergent powder is priced at ₹ 30 for its suppliers. One of its suppliers purchases 16,000 packs per annum. The supplier incurs an ordering cost of ₹ 350.00 per order and has a carrying cost of 12% of the inventory value. Hindustan Lever 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?

Self Assessment

Notes

Fill in the blanks:

10. Too much or too little, or the wrong inventory, all have detrimental impacts on operational and …… results.
11. A …… turnover ratio reflects that there are less idle resources in the company, and therefore the company is using its inventory efficiently.
12. Economic batch quantity is a measure employed to determine the quantity of units that can be produced at …… costs in a specified batch or production run.
13. Hypothesis is rejected when it is true is called …… error.
14. Hypothesis is not rejected when it is false is called …… error.
15. A statistical hypothesis test is a method of making statistical decisions using …… data.

Case Study

Gunny Bags Inventory at Western India Cement Company

The Western India Cement Company (WICC), a reputed and large Cement Manufacturer operates an one million Tonne Cement plant at Cement Nagar in Western India. The plant has access to high quality limestone in close proximity of the plant. Due to this, WICC has a Competitive edge in terms of cost of production and quality of Cement. However, WICC is not so fortunate in respect of some of the other materials it consumes, particularly coal and Gunny bags.

WICC has to put up with low quality (High Ash content) of coal and also irregular supply. In addition there is long haulage for Coal. WICC manages its Coal requirements though adequate stock of Coal along with occasional purchase from open market and road transport.

The situation in respect of Gunny bags is somewhat different. The availability of Gunny bags is not a serious issue but the cost incurred on maintaining the Gunny bags inventory is of concern to the management of WICC.

Almost the entire quantity of Cement produced in the Country is despatched through 50 Kg bags. The bulk transport of Cement, as in developed Countries, is yet to be accepted widely in India.

There are some choices in respect of the Bags for transportation of Cement: in the form of paper, polythene, Gunny Bags – with or without polythene lining, etc. The Government of India has been consistently advocating and continuously supporting the use of Gunny bags for Cement transportational partly to keep the Jute Industry viable and also for energy and environmental considerations. WICC has been as a policy using Gunny bags for the entire transportation requirements of Cement.

The total requirement of Gunny bags for a 1.0 million Tonne plant comes to 20.4 million bags per year, considering burstage and other losses of about 2%. The annual expenditures on procurement of Gunny Bags comes to ₹ 20.4 crores at an average cost of ₹ 10.00 per bag. This being a high consumption value item it becomes essential to monitor its supplies on a regular basis, so that there is no abnormal increase in the inventories as also the plant is

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Notes

adequately catered against stockouts. The month-wise receipts and consumption pattern of Gunny bags for the years 1989, 1990, and 1991 have been presented in Appendix - 1, Appendix - 2 and Appendix - 3 respectively.

Calcutta is the major source of Gunny bags in the Country. Almost entire quantity of Gunny bags requirement of WICC is obtained from Calcutta. There is no major bottleneck in the availability of Gunny bags. However, there is variation in the transportation time of Gunny bags from Calcutta to the works of WICC. The bags are despatched from Calcutta by goods train to Delhi. Once the wagons arrive in Delhi, the bags are unloaded within 5 hours and loaded on to trucks for transportation to the works site. Past records of railway receipts received from Calcutta and the date on which the bags were received at the factory indicates that on an average 12 days (Appendix - 4) are required from the day the materials are despatched from Calcutta till it reaches the factory. Normally monthly orders are placed by the Purchase Division. The despatches from Calcutta are regulated through despatch advice communicated periodically through telex/fax.

The expected monthly requirement of bags for the year 1992 have been furnished in Appendix - 6. It is desired to finalise the procurement and inventory policy in respect of Gunny bags for the year 1992 in order to minimise the total cost related to Gunny bags.

The Purchase Division has indicated an ordering Cost of ₹ 740/order (Appendix - 5). The cost of each Gunny bag can be taken to be ₹10.00 per bag.

Comment on the Compensation of Ordering Cost. Suggest an alternate (better) method if any. Also indicate how the inventory carrying cost (which has been estimated to be 21%) needs to be computed.

Suggest a procurement and inventory policy for Gunny Bags for the year 1992, with cost and consumption and other data provided in the case.

Appendix 1: Statement Showing Month-wise Receipt and Consumption of Gunny Bags for 1989

Month	Opening Stock	Receipt	Consumption	Closing Stock
January	1624628	1770000	803189	2591439
February	2591439	80000	688372	1983067
March	1983067	-	850059	1133008
April	1133008	450000	621129	961879
May	961879	948500	735840	1174539
June	1174539	1437625	653332	1958832
July	1958832	573000	861061	1670771
August	1670771	476125	722555	1424341
September	1424341	287500	829322	882519
October	882519	867752	926057	824214
November	824214	1034209	904917	953506
December	953506	1354250	920334	1387422
Total		9278961	9516167	16945537

- Average monthly closing stock = 16945537/12 = 1412128
- Average monthly receipt = 9278961/12 = 773246
- Average monthly consumption = 9516167/12 = 793014

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Appendix 2: Statement Showing Month-wise Receipt and Consumption of Gunny Bags for 1990

Month	Opening Stock	Receipt	Consumption	Closing Stock
January	1387422	904472	855671	1436223
February	1436223	356832	560734	1232321
March	1232321	1099879	587368	1744832
April	1744832	392577	778870	1358539
May	1358539	508736	976932	890343
June	890343	1035135	789330	1136148
July	1136148	732383	815240	1053291
August	1053291	798005	950996	900300
September	900300	969893	746705	1123488
October	1123488	500530	675513	948505
November	948505	573571	755735	766441
December	766441	781330	1046812	500959
Total		8653443	9539906	13091390

Notes:
1. In consumption figures of May, 99983 bags are included which were destroyed due to fire.
2. 25,000 bags sent for repairing in the month of October.
3. 9850 bags sent for repairing in the month of November.

- Average monthly closing stock is = 13091390/12 = 1090949
- Average monthly receipts = 8653443/12 = 721120
- Average monthly consumption = 9539906/12 = 794992

Appendix 3: Statement Showing Month-wise Receipt and Consumption of Gunny Bags for the Year 1991

Month	Opening Stock	Receipt	Consumption	Closing Stock
January	500959	909450	751815	658594
February	658594	475830	452478	681946
March	681946	1091125	630922	1142149
April	1142149	1030000	730675	1441474
May	1441474	263250	825397	879327
June	879327	391500	774885	495942
July	495942	1363900	818618	1041124
August	1041124	587400	594647	1033877
September	1033877	727640	467580	1292927
October	1293937	480840	571630	1203147
November	1203147	419700	663255	959592
December	959592	415600	790628	584564
Total		8156235	8072530	11415673

- Average monthly closing stock = 11415673/12 = 951306
- Average monthly receipts = 8156235/12 = 679686
- Average monthly consumption = 8072530/12 = 672711

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Appendix 4: Receipt Frequency of Gunny Bags in 1991 (No. of Days in Transit taken from date of R/R till the date of Receipt at Works) Instances of No. of Days in Transit

Months	No.of Trucks Received	10 days	11 days	12 days	13 days	14 days	15 days
January	42	2	2	35	3	-	-
February	26	2	3	16	5	-	-
March	57	3	3	47	4	-	-
April	52	-	4	40	4	2	2
May	20	-	3	12	2	1	2
June	24	-	4	16	3	1	-
July	61	-	9	46	4	1	1
August	33	-	2	26	3	1	1
September	37	-	7	25	3	1	1
October	26	2	5	13	5	-	1
November	22	3	2	13	3	1	-
December	23	1	2	17	3	-	-
Total	423	13	46	306	42	8	8

Average No. of days in transit= (13*10*11+306*12+42*13+8*14+8*15) / 423
= (130+506+3672+546+112+120) /423
= 5086/423 = 12.02 Say 12 days.

Appendix 5: Computation of Ordering Cost

Purchase Department, New Delhi, has furnished the following information in connection with the Purchase orders released both from Delhi and Plant Office as also the establishment charges for both the places:

A. No. of Orders Released:

(a) From New Delhi 13210 Nos.

(b) From PLANT 806 Nos

Total 2126 Nos.

B. In addition to the above, one order per month is released for Coal and two orders per month for Diesel.

C. Total no. orders released would be:

(a) No. of orders from Delhi & PLANT 2126 Nos.

(b) No. of orders from Coal 12 Nos.

(c) No. of orders for Diesel 24 Nos.

Total 2162 Nos.

D. Establishment Costs of Purchase Department at Head Office & PLANT Office (Based on the information furnished by Manager (Accounts)), New Delhi = ₹ 16 lakhs

E. Ordering Cost ₹ 16 lakhs / 2162 = ₹ 740 per order.

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Notes

Appendix 6: Requirement of Gunny Bags for 1992
(One tonne =20 gunny bags, 2% extra bags required due to burstage)
(Quantity in Tonnes & Nos.)

Month	OPC Cement Despatch (in Tonnes)	PPC Cement Despatch (in Tonnes)	Total Cement Desptach (in Tonnes)	OPC (Requirement of bags in Nos.)	PPC (Requirement in Nos.)	Total (Requirement in Nos.)
January	12350	18500	30850	251940	377400	629340
February	15500	23250	38750	316200	474300	790500
March	18500	27700	46200	377400	565080	942480
April	17300	25900	43200	352920	528360	881280
May	17300	25900	43200	352920	528360	881280
June	15600	23400	39000	318240	477360	795600
July	17600	26300	43900	359040	536520	895560
August	18800	28200	47000	383520	575280	958800
September	18200	27200	45400	371280	554880	926160
October	17600	26300	43900	359040	536520	895560
November	17900	26900	44800	365160	548760	913920
December	19200	28800	48000	391680	587520	979200
Total	205850	308350	514200	4199340	6290340	1048960

- Average Requirement of OPC bags/month = 4199340/12 = 349945, say 350000
- Average Requirement of PPC bags/month = 6290340/12 = 524195, say 525000
- Average Requirement of bags/month = 10489680/12 = 873390, say 875000

Questions

1. Analyse the case and bring out the main problems in the case.
2. Suggest alternate ways for effective management of gunny bags inventory.

Source: Upendra Kachru, *Production and Operations Management – Text and Cases,* First Edition, Excel Book, New Delhi, 2007.

9.5 Summary

- Inventory can have a significant impact on both a company's productivity and its delivery time.
- The costs generally associated with inventories are Holding (or carrying) cost, Cost of ordering, Set up (or production change) costs and Shortage or Stock-out Costs.
- The heart of inventory analysis resides in the identification of relevant costs.
- 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.
- The VED Classification is based on the criticality of the inventory item. 'V' stands for vital, 'E' for essential, 'D' for desirable.
- The rupee value of a company's average level of inventory is one of the most common measures of inventory.
- The optimum quantity (lot size) using a tabular approach is called the Economic Order Quantity (EOQ).

Notes

- If you have both demand and delivery (lead time) uncertainty, you must use a convolution formula (Bowersox 2010) to calculate the safety stock level.
- The two types of errors in statistical hypothesis test are Type 1 error and Type 2 error.
- Economic batch quantity (EBQ) is a measure employed to determine the quantity of units that can be produced at minimum average costs in a specified batch or production run.

9.6 Keywords

Economic Order Quantity (EOQ) Model: The basic model concerned primarily with the cost of ordering and the cost of holding inventory.

Economic Batch Quantity (EBQ): It is a measure employed to determine the quantity of units that can be produced at minimum average costs in a specified batch or production run.

Inventory: It means any stock of direct or indirect material kept and stocked in order to meet the expected and unexpected demand in the future.

Inventory Turnover Ratio: It is the ratio of the company's sales to its average inventory investment.

Re-order Level: The inventory level at which the order is released is known as the reorder level.

9.7 Review Questions

1. What is economic order quantity (EOQ)? Explain the EOQ model of inventory with its simplifying assumptions.
2. How is the model of inventory used by a manufacturer different from a retailer?
3. Inventory control system may need to be modified as demand, costs, and competitive pressures changes. What are the parameters that should be reviewed for reorder systems?
4. What is the cost of uncertainty in demand during lead time?
5. How the EOQ model works with varying lead time and with varying demand?
6. 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.
7. A price discount schedule for an item that we purchase is offered as follows: ₹ 1.00 per unit in quantities below 800, ₹ 0.95 per unit in quantities of 800 to 1599, and ₹ 0.90 per unit in quantities of 1600 or more. The requirement is 1600 units per year; the purchase order cost is ₹ 50.00 per order; and inventory holding costs are 10 per cent of the average inventory value per year, or ₹ 0.10 per unit per year at the ₹ 1.00 per unit price. The value of EOQ is 400 units. What should the purchase quantity be in order to take advantage of the price discount?
8. What are the functions of inventory that assist the organization in accomplishment of its goals?
9. Explain the various costs associated with inventory.
10. The ABC classification is based on focusing efforts where the payoff is highest. Explain.

Notes

Answers: Self Assessment

1. overtime
2. precisely
3 larger lot-size
4. inventory
5. shortage
6. fixed, vary
7. payoff
8. criticality
9. vital
10. financial
11. higher
12. minimum average
13. Type I
14. Type II
15. experimental

9.8 Further Readings

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Unit 10: Building of a Supply Chain

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10.4 Sourcing Strategy

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10.4.2 Network Sourcing Strategy

10.4.3 Single Sourcing Strategy

10.5 Summary

10.6 Keywords

10.7 Review Questions

10.8 Further Readings

Objectives

After studying this unit, you will be able to:

- Explain the orientation and implementation of supply chain function;
- Describe the supply chain processes in an organization;
- Differentiate the single sourcing and multiple sourcing strategy.

Introduction

The business 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. Focusing on the management of these factors was critical. The key factors that allowed organizations to compete successfully, was to find solutions in all these areas.

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10.1 Orientation of Supply Chain Function within an Organization

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:

10.1.1 Supply Chain Design

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.

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.

Caution It is to be kept in mind that successful design requires a high degree of functional and organizational integration.

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 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. In the case of TI Cycles discussed in earlier unit, 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.

Did u know? Supply Chain Design is a strategic decision.

10.1.2 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.

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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.

- SCM endeavours 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.
- 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.
- 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.

10.1.3 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.

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.

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.

Did u know? The output from aggregate planning is also of value to both upstream and downstream partners.

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

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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.

Self Assessment

Fill in the blanks:

1. …… reflects the structure of the supply chain over the next several years.
2. After identifying the key supply chains, one must identify the supply chain …… that are considered most critical to the organization's supply chain management efforts.
3. The …… plan serves as a broad blueprint for operations and establishes the parameters within which short-term production and distribution decisions are made.
4. …… plans for an organization define demand from suppliers and establish supply constraint for customers.

10.2 Implementation of Supply Chain Function within an Organization

10.2.1 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 multi-divisional, 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: 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.

10.2.2 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

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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.

Self Assessment

Fill in the blanks:

5. The …… supply chain is that portion of a given supply chain that occurs within an individual organization.
6. The supply chain has to be seen as a set of …… processes rather than a series of discrete, non-aligned activities.
7. Developing supply chain …… for major supply chains and their related processes is a basic requirement to establish an effective supply chain.

10.3 Supply Chain Processes in an Organization

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. There are two different ways to view the processes performed in a supply chain, (a) the push-pull view and (b) the cycle view.

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).

Example: 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 10.1 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.

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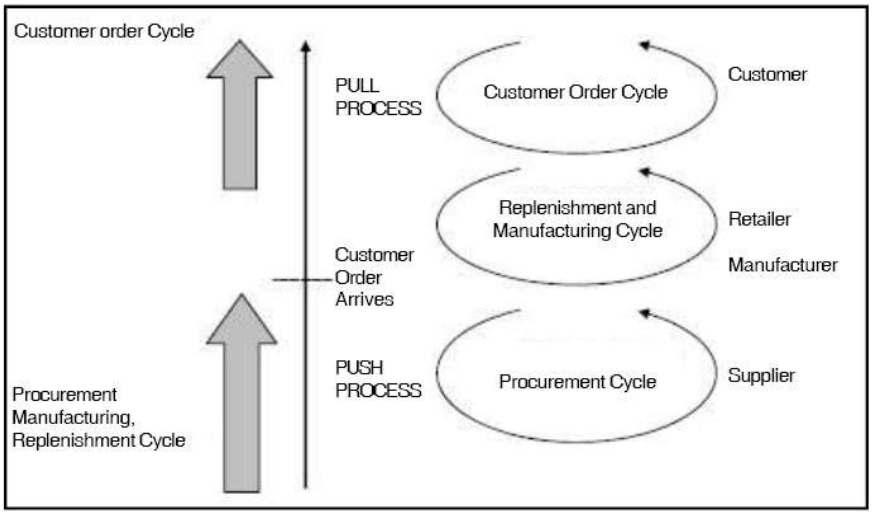
Figure 10.1: Push/Pull Processes for a Retail Network



Notes 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.

Self Assessment

Fill in the blanks:

8. A supply chain is a …… of processes and flows that take place within and between different stages and combine to fill a customer need for a product.
9. There are two different ways to view the processes performed in a supply chain which are the push-pull view and the …… view.
10. …… processes are initiated by a customer order.
11. …… processes are initiated and performed in anticipation of customer orders.

10.4 Sourcing Strategy

The decision to source is determined by the strategy the firm may have for that category of item. There are basically three sourcing strategies that are combined in different ways. These strategies are:

1. Multi-sourcing Strategy
2. Network Sourcing Strategy, and
3. Single Sourcing Strategy

The strategic issues involved in each of these sourcing strategies are discussed below.

Notes

10.4.1 Multi-sourcing Strategy

Traditional purchasing was dominated by a multi-sourcing strategy. This meant that the firm had business relationships with a number of suppliers. The base of suppliers was large and the duration of contracts was short. Suppliers would be sent enquiries and they would respond with quotations, meeting the demands and specifications of the firm, and negotiate with purchasing for the contract.

This approach was based on the perception that certain advantages accrue to the buying company. These include:

1. Creating competition by playing one supplier against another.
2. Obtaining bids with low prices and shipping costs.
3. Increasing leverage over suppliers.
4. Greater degree of flexibility in technical areas, and
5. With a number of sources, it provided protection in times of shortages against failure at any one supplier's plant.

From the buyer's point of view, the responsibility to maintain the necessary technology, expertise, and forecasting abilities plus cost, quality, and delivery competencies lay with the supplier. However, dealing with several suppliers required a longer time in negotiation that could often result in a delay or disturb the buyer's production schedules.

The approach placed emphasis on achieving the lowest possible price for a particular product. Long-term partnership was not the goal of the buying firm and the initial price was more important than the total price of a product.

The multiple sourcing was, therefore, a preferable and suitable purchasing alternative. Transactional relationships were the desired outcome. In today's environment, multiple sourcing is generally limited to and used for commodity items, non-strategic buying and standard items.

There has been a change from the traditional model. The number of suppliers to use for one type of purchase has changed to the use of fewer, reliable suppliers and even to the extent of using sole or single suppliers.

Buyer-supplier relationships, in integrated supply chains, have evolved into trusting, cooperative, and mutually beneficial long-term relationships. Firms' today reduce their supply base to only the best suppliers, while further developing suppliers who are continuously improving their quality, delivery, service, price, and information performance.

10.4.2 Network Sourcing Strategy

Many firms have successfully consolidated their supplier bases by using a phased approach. This hybrid is often termed networking.

In networking, bought in content of the final product is based on the skills and specialized knowledge of different tiers of subcontractors. The supply network is a hierarchical pyramid. The top tiered suppliers are the most skilled and possess the most advanced technologies, while the suppliers at the bottom have adequate skills for their particular operations. Communication is shared between the buyer and all the suppliers within the network.

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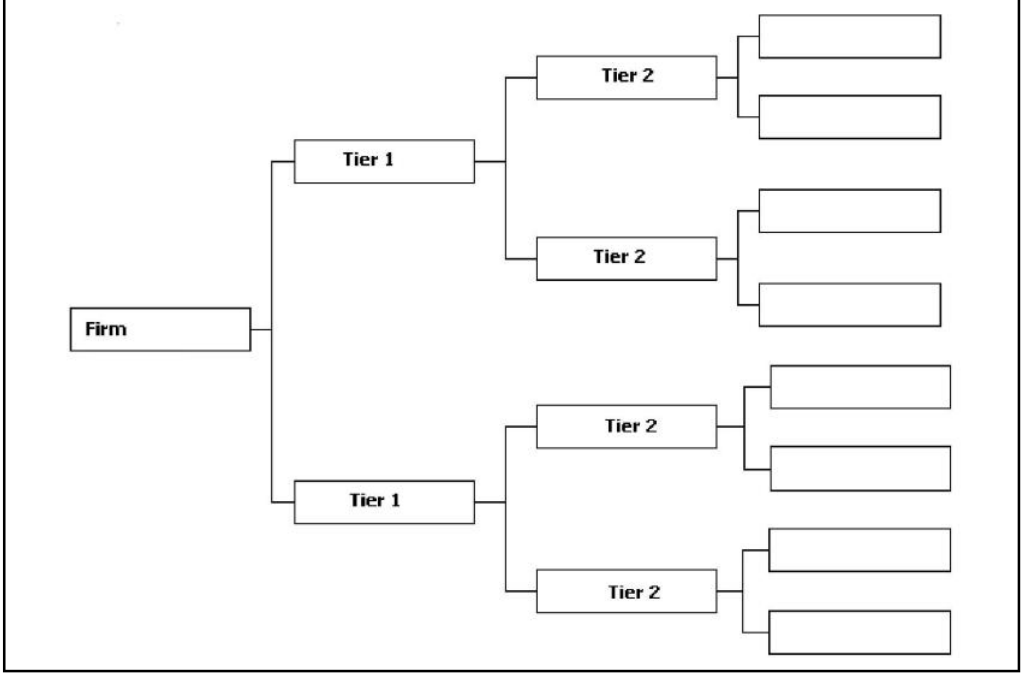
Figure 10.2: Network Sourcing



Generally, the suppliers at the first tier are largely responsible for complete systems, whereas those at the lower tiers become subcontractors to the upper level suppliers providing individual components. In this way, the number of supply sources can be reduced and the impact of the network is enhanced due to the transfer of technology between the firms.

The system is similar to the multi-sourcing system in that, typically, but not exclusively, it relies on multiple sources for the parts or services purchased. The key point is that the purchasing expenditure is maximized within a pre-selected and relatively long lasting array of sources. In this type of system, some suppliers may be direct competitors.

Generally, manufacturing organizations with an assembly-type of operation choose network sourcing as the sourcing choice. This sourcing alternative is particularly appropriate to industries with a heavy reliance on a high purchased content of parts designed and made uniquely for the particular assembler under consideration. Automobile producers, such as Maruti or Hyundai, find this mode of purchasing particularly beneficial.

Companies that have traditionally used vast numbers of suppliers have successfully made the transition to best practice in supply management by reducing their supplier base by 50 percent or more. However, it is not easy. Most companies and suppliers go through three phases before achieving a healthy relationship.

In the beginning, an obvious distrust exists: the company is evaluating its suppliers' performance and deciding whether to retain or drop them. During the second phase, successful companies develop long-term agreements with their best suppliers as a basis for good relationships. Over time, such agreements will, in conjunction with supplier training and dedicated company teams, build a strong supplier base with high technical capabilities and greater willingness to share information.

The advantages of network sourcing allow a company to outperform competitors who use multiple sourcing, especially in areas such as cost reduction, improved communication, flexibility, and stability. This has made it a very attractive step for companies as they move to 'World-class Supply Management'.

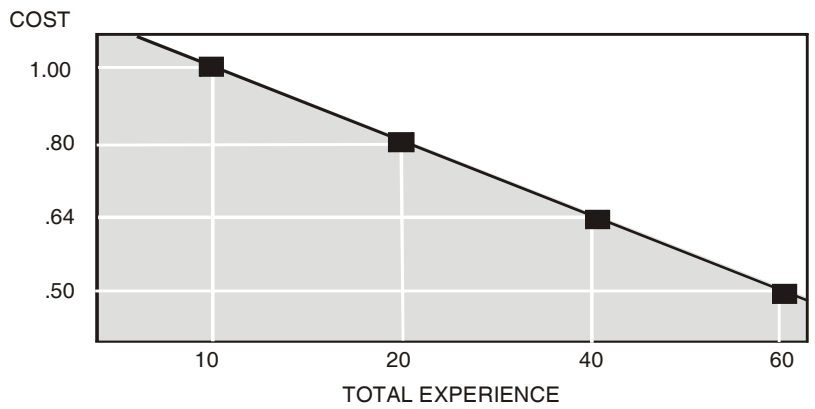
Notes

10.4.3 Single Sourcing Strategy

Single sourcing as a concept evolved from the work carried out by the Boston Consulting Group (BCG) in the 1960s. The breakthrough came while BCG was working for a major manufacturer of semiconductors. In a study on the cost of television components BCG found striking differences in the rate of cost improvement between monochrome parts and color parts. This was difficult to explain since the same factory, the same labor, the same processes were involved at the same time. BCG explained the phenomenon through the experience curve.

BCG had earlier observed in many of their studies that producers tend to become increasingly efficient as they gain experience in making their product, and costs usually declined with cumulative production. They came up with a hypothesis to explain how an organization with the greatest accumulated volume of production will have the lowest cost relative to other producers in the market. This explained why monochrome parts had progressed down a cost curve to a larger degree than the color parts. The accumulated experience in monochrome parts was much greater than in color parts.

Figure 10.3: The Experience Curve



The experience curve is shown as Figure 10.3. According to the experience curve concept, costs of value added decline approximately 20 to 30 percent in real terms each time accumulated experience is doubled. If the growth rate is constant, the cost decline continues indefinitely as long as the growth rate continues. If the growth stops, costs continue to decline, but the rate of decline is cut in half each time the accumulated experience doubles.

The cost declines identified by the experience curve do not occur automatically. It is assumed that there is added investment in an amount commensurate with the marginal cost of capital. Study of the experience curve shows, if high return on investment thresholds is used to limit capital investment, then costs do not decline as expected.

BCG was able to collect the evidence on a wide variety of semiconductors that were a part of the original study. Price data supplied by the Electronic Industries Association was compared with accumulated industry volume. Two distinct patterns emerged:

- In one pattern, prices, in current dollars, remained constant for long periods and then began a relatively steep and long continued decline in constant dollars.
- In the other pattern, prices, in constant dollars, declined steadily at a constant rate of about 25 percent each time accumulated experience doubled.

This pattern seemed to have applicability across the board. Systematic cost differences arise between competitors because some develop more knowledge about production than others.

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This concept has important implications: if a company can accelerate its production experience, it could gain a cost advantage in its industry that would be difficult to match.

This linear relationship between costs and cumulative production became known as the Experience Curve.

Notes The Experience Curve has had profound implications for business thinking and practice. As a strategic concept, you can predict cost declines with experience due to large scale procurement and the relative experience between the different suppliers can be used to provide competitive advantage.

Consolidation alone, however, does not provide the complete competitive advantage. The advantage is enhanced when limited resources can be focused on a manageable number of suppliers, which can then receive the attention they need to achieve top performance. Relationships with suppliers improve since there is no competition between suppliers and company. Once the supplier and manufacturer begin working together and a long-term commitment is established, the need for additional suppliers also diminishes.

Eliminating redundancy also reduces overall costs, cutting out dual sourcing, dual tooling, and dual process development. With the security of part-for-life agreements, suppliers are much more open to suggestions about cost reduction and are more willing to invest in optimizing their processes. Suppliers receive enough volume from the company to warrant investing their own internal resources to optimize their production process and thus produce a component at a more competitive price.

For example, one firm had over 300 suppliers in the late 1980s. It identified the following problems which resulted in high costs for purchased materials and low profitability:

- Many suppliers were low-quality manufacturers;
- Many were geographically dispersed; and
- There were multiple suppliers for the same part family, so that suppliers saw no long-term economic gain in working with the company.

The company undertook a three-part initiative to consolidate its supplier base and upgrade its approach to supply management:

1. The first phase eliminated suppliers that were poor-quality performers or whose relationships with the company were irreparable.
2. The next phase was to train the remaining suppliers in just-in-time, statistical process control, and continuous improvement. They were asked to develop plans to meet the new cost, quality, and delivery goals required for just-in-time. After evaluating these plans, the company eliminated more suppliers.
3. In the last phase, the remaining suppliers of the company were asked to invest in value engineering to reduce the cost of the part to the company. The company supported them through dedicated teams who visited suppliers' factories and help improve their manufacturing operations.

As the suppliers had sufficient volume to justify making improvements to tooling and operations, the company was able to improve the quality and reduce the total costs of the product significantly, allowing the company to advance from a declining 17 percent market share in 1982 to the 83 per cent market share, it enjoys in 2005.

Notes

Caution In a single sourcing relationship, all suppliers are treated equally, whether they are internal or external.

Suppliers set their own goals and evaluate their own performance. The company monitors their goals and encourages them continually to improve their performance. Where it feels the goals are too low, the company provides support for process and operations improvement.

Orders are understood to be placed at current prices and there are no annual price re-negotiations. Company and suppliers constantly work together to reduce the cost of purchased materials. Using this approach, most companies are able to cut material costs significantly. Suppliers are expected to make up for any increases in the cost of raw materials that arise from normal inflation, but they are compensated for unusual swings in the raw materials market.

Japanese just-in-time (JIT) philosophy, which has been growing in popularity, has also played a major part on giving this concept the legitimacy it needed. The central idea of JIT is to eliminate waste and to emphasize value added activities. This also involves reducing the number of suppliers a firm does business with. The purchasing objectives have a focus to consolidate a partnership or alliance with the supplier.

Relationships built on trust and mutual understandings have allowed companies to simplify their contracts to straightforward two to three-page agreements. That the supplier has the part for the life of the product is understood. However, developing this type of relationship generally takes a five to eight-year effort for both parties. The best place to start is with A category products (ABC analysis), as these tend to provide the greatest initial benefits.

Once the company outsources a part, its supplier keeps the part for life unless a quality or delivery problem arises. Eliminating redundancy reduces overall costs, cutting out dual sourcing, dual tooling, and dual process development.

Single sourcing is preferred as the purchasing method, when the strategic emphasis is on the supplier's availability of technical support, the reliability of the product, and the total cost of the product. As companies gain experience with single-sourcing, they tend to move beyond individual parts to entire part families, further reducing the complexity of supplier management.

Successful day-to-day collaboration between a company and its suppliers relies on supplier evaluation, investment for improvement, integration of suppliers, effective use of transportation, and open communication.

Table 10.1: Advantages and Disadvantages of Single Sourcing

Buyers' perspective 1. Improved communication from the close buyer-seller relationship 2. To cooperatively design quality system and to share quality output data 3. Lower price stemmed from reduction of costs in ordering, shipping, and material handling 4. Improved stability for both parties	1. A strike or a production resulted disruption could cause major difficulties 2. The absence of bargaining control power a buyer has in dealing with a single source 3. The relationship must be a genuine cooperation
Vendor's perspective 1. Quality considerations 2. Cost considerations 3. Dependability 4. Flexibility of reacting to demand and environmental changes	1. Without competition the vendor may attempt to cut costs 2. Vendor needs to exercise great care when negotiating a contract

Notes

In conclusion, the advantages and disadvantages of single sourcing, both from the buyer's perspective as well as the vendor's perspective are shown in Table 10.1.

Task What are the advantages of 'single sourcing' over 'networking'? Which option would you choose for a machine tool manufacturing unit and why?

Self Assessment

Fill in the blanks:

12. Generally, manufacturing organizations with an assembly-type of operation choose …… sourcing as the sourcing choice.
13. Traditional purchasing was dominated by a …… strategy.
14. According to the experience curve concept, costs of value added decline approximately 20 to 30 percent in real terms each time accumulated experience is …… .
15. Single sourcing is preferred as purchasing method, when strategic emphasis is on the supplier's availability of technical support, the reliability of the product, and …… of the product.

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. 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.

Contd...

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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 AFACON 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.

10.5 Summary

- Supply chain design reflects the structure of the supply chain over the next several years.
- In the Supply Chain planning phase, companies define a set of operating policies that govern short-term operations and are normally determined on an annual basis.
- Aggregate planning is the basis for decisions at Supply chain operations stage.
- The internal supply chain is that portion of a given supply chain that occurs within an individual organization.
- Once the decision is made to purchase a product or service from external suppliers, purchasing is brought into the process.

Notes

- There are two different ways to view the processes performed in a supply chain which are the push-pull view and the cycle view.
- Pull processes are initiated by a customer order whereas push processes are initiated and performed in anticipation of customer orders.
- The decision to source is determined by the strategy the firm may have for that category of item.
- There are basically three sourcing strategies that are combined in different ways. These strategies are Multi-sourcing Strategy, Network Sourcing Strategy and Single Sourcing Strategy.
- This linear relationship between costs and cumulative production became known as the Experience Curve.

10.6 Keywords

Cycle View: A view of supply chain when the processes are divided into a series of cycles, each performed at the interface between two successive stages of a supply chain.

Internal Supply Chain: It is that portion of a given supply chain that occurs within an individual organization.

Pull Processes: These are processes in a supply chain initiated by a customer order.

Push Processes: These are processes in a supply chain initiated and performed in anticipation of customer orders.

Supply Chain: It consists of organizations that are connected through three key flows across their boundaries—flow of information, product/materials, and funds between the different stages.

10.7 Review Questions

1. Orientation of Supply chain Function requires considering supply chain design aspects within an organization. What are the supply chain design considerations?
2. Describe the significance of Supply Chain Planning.
3. Aggregate planning is the basis for decisions at supply chain operations stage. Explain.
4. Implementation of supply chain considers two significant aspects. What are those? Explain them.
5. 'The supply chain has to be seen as a set of interrelated processes rather than a series of discrete, non-aligned activities.' Justify.
6. What are the different ways to view the processes performed in a supply chain?
7. 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. Explain.
8. Explain the sourcing strategy by which the traditional purchasing was dominated.
9. 'Many firms have successfully consolidated their supplier bases by using a phased approach.' Explain the sourcing strategy which signify the statement.
10. Describe the sourcing strategy of supply chain which evolved from the work carried out by the Boston Consulting Group (BCG) in the 1960s.

Notes

Answers: Self Assessment

1. Supply Chain Design
2. member organizations
3. aggregate
4. Production
5. internal
6. interrelated
7. process maps
8. sequence
9. cycle
10. Pull
11. Push
12. network
13. multi-sourcing
14. doubled
15. the total cost

10.8 Further Readings

Books

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

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Online links

www.exforsys.com/tutorials/supply-chain/scor-model.html

www.logisticsmgmt.com

Unit 11: Facility Planning and Layout

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Objectives

After studying this unit, you will be able to:

- Recognize the thought of facility planning;
- Describe the different types of layout;
- Differentiate the various types of layouts;
- Discuss the application of layout to service industry.

Introduction

Good micro level planning can affect an organization and determine how well it meets its competitive priorities by Facilitating the easy flow of materials and information, Increasing the efficiency in the utilization of labour and equipment, Increasing convenience of customers and thereby sales at a retail store, Improving working conditions and decreasing hazards to workers, Improving employee morale, and Improving communication.

11.1 Facility Planning

Facility planning at the micro level involves decisions about the functional layout and physical arrangement of economic activity centers: it could be a teller window in a bank or the space for

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customers to wait for their turns; it could be a machine, a workbench or workstation; 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.

Example: A central tool room is often efficient for most processes, but keeping tools at individual workstations 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.

Did u know? **What is Economic Activity center?**

Economic activity centers are work related places that consume space.

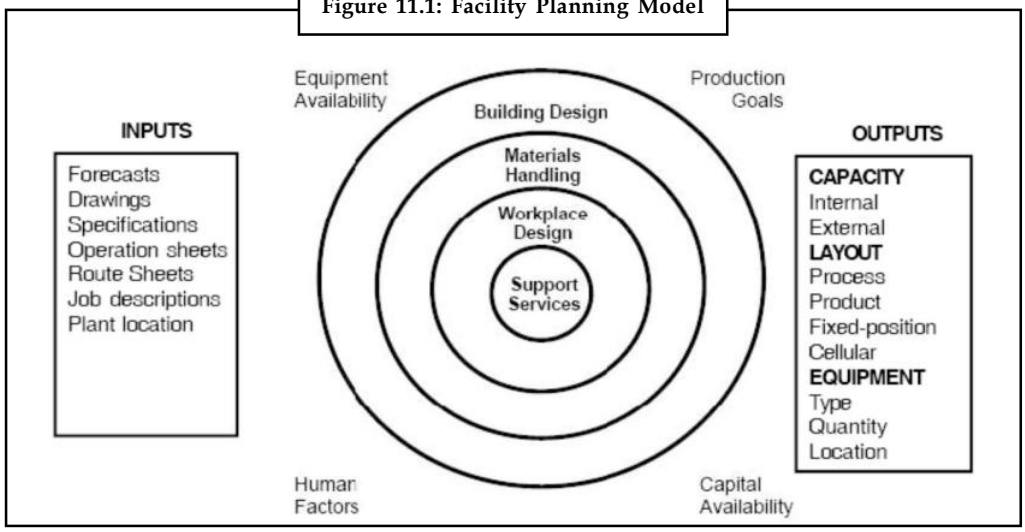
The location of an economic activity center has two dimensions that affect a center's performance:

1. Relative location, or the placement of a center relative to other centers, and

2. 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.

Figure 11.1: Facility Planning Model



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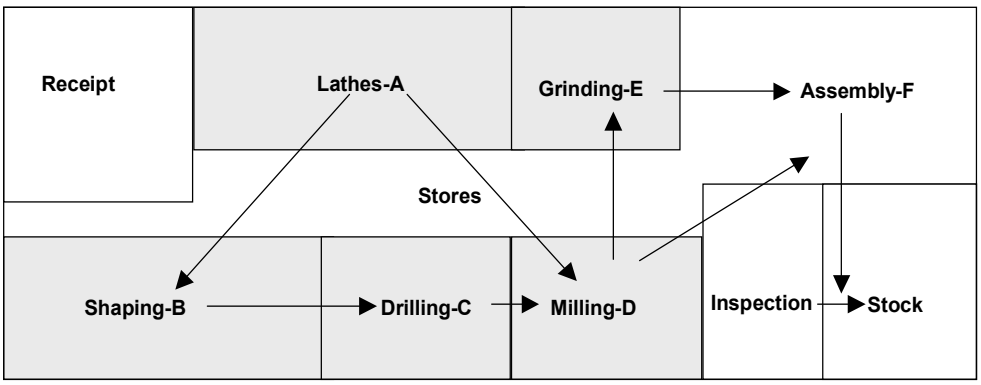
The operations function in both manufacturing and service organizations can be divided into two basic types, intermittent and continuous, according to the volume and standardizing of the product or service.

Different types of operations have different layout requirements. By their nature, layouts of the facility are one of the most important strategic elements of a business enterprise. Many symptoms of inappropriate business architecture appear as layout or material handling issues.

Example: In warehouses, materials flows and the cost of picking stocks are dominant considerations; in retail outlets, customer convenience and sales may dominate; whereas in an office, communication effectiveness and team building may be crucial.

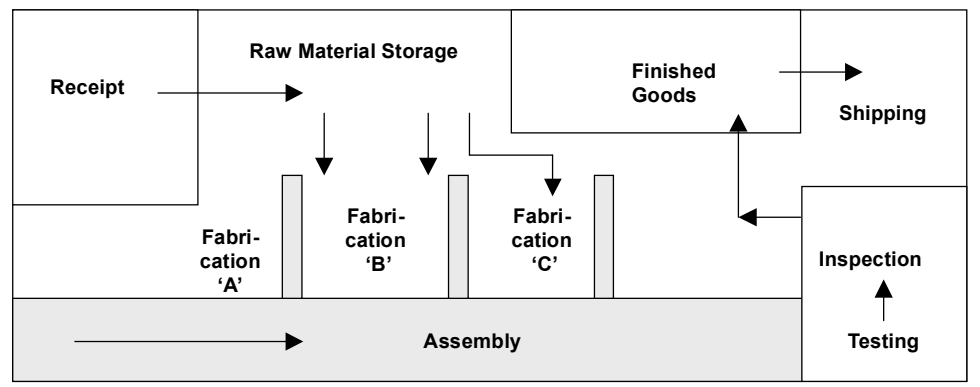
Intermittent Operations: Intermittent operations are characterized by the work piece moving from one group of machines to another. It finds application in made-to-order products, low product volume, general-purpose equipment, labour-intense operations, interrupted product flow, frequent schedule changes, and large product mix. An example is a machine shop. Figure 11.2 reflects a typical process layout.

Figure 11.2: Functional Process Layout



Continuous Operations: Standardized products of high product volume characterize continuous operations. Special purpose equipment and capital-intensive operations with continuous product flow characterize these layouts. There is a small product mix and products are made to store as inventory, i.e., they are available off the shelf. The layout of continuous flow is shown in Figure 11.3.

Figure 11.3: Layout for Continuous Operations



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The problem of layout continuous inflow (product layout) and job shop (process layout) are different in nature. The primary problem in product layout is of line balancing. In process layout, the objective is to find out the most economic arrangement of various departments (or machine centers) in a manufacturing organization.

Self Assessment

Fill in the blanks:

1. At the micro level facility planning involves decisions about the ……..layout and physical arrangement of economic activity centers.
2. ……...operations are characterized by the work piece moving from one group of machines to another.

11.2 Types of Layout

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

1. Space Planning Units (SPUs)
2. Affinities
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

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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

Caution 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.

Self Assessment

Fill in the blanks:

3. The layout should be based on the premise that a properly designed facility is an important source of …… advantage.
4. The layout should facilitate arrangement of physical facilities, which allows most efficient use of men, machines and …… necessary for the operation to meet the requirements of capacity.

11.3 Process Layout

Process layout is also known as functional layout. Similar machines or similar operations are located at one place as per the functions.

Example: As will be apparent from Figure 11.4, 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.

11.3.1 Process Layout and Material Handling Costs

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. We have studied the Load-Distance Model previously, which is a simple mathematical model that

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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.

11.3.2 Optimisation in Process Layouts

Spiral Analysis-Use of Schematic Diagram to Solve Layout Problem

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 11.4. 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 11.1.

Table 11.1: 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	

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.

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 11.4). 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

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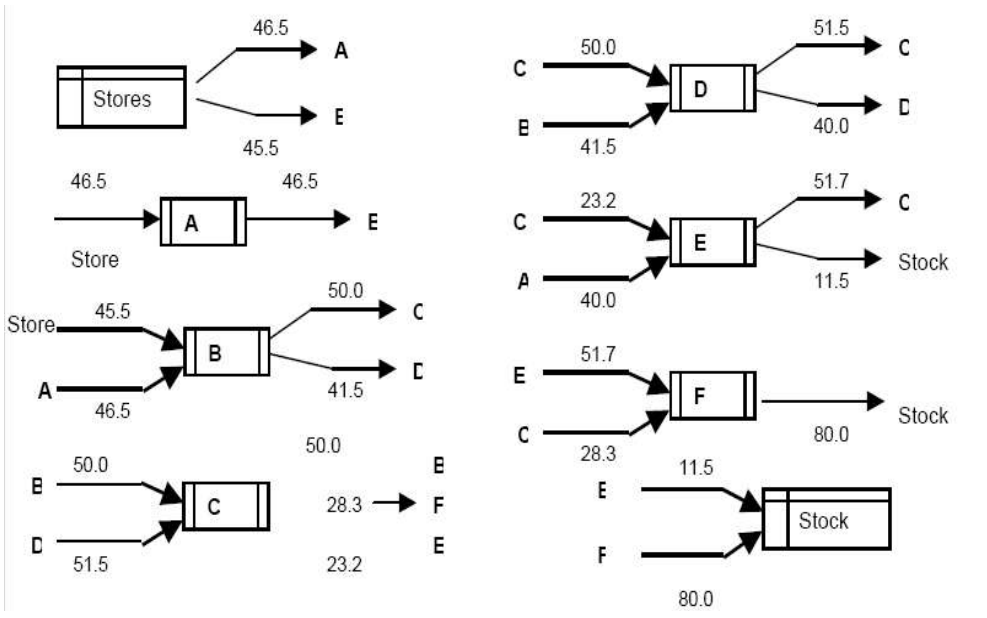
ABC analysis of inventory systems, products that do not have significant effect on the total production pattern, have not been shown in Table 11.1. However, care must be taken to ensure all significant products and product groups are included.

Figure 11.4: 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 11.5. 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.

Example: Take the store figures. The total that leaves the store has to equal 91.5, the figure given in Table 11.1. 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.

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 11.2.

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Table 11.2: 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

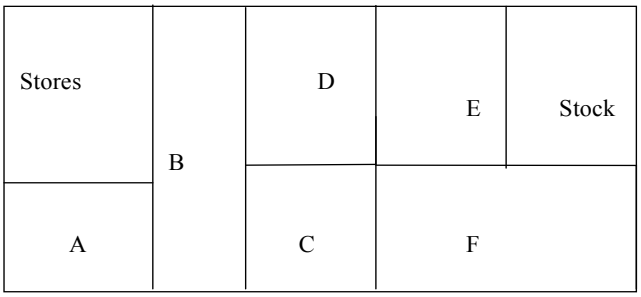
The spiral method works under following assumptions:

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.

Figure 11.5: A feasible Arrangement by using the Spiral Method



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 above.

Computerized Relative Allocation of Facilities Technique (CRAFT)—Use of Software to solve layout problem

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

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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.

11.3.3 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.
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.

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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.

Self Assessment

Fill in the blanks:

5. Process layout is also known as …… layout.
6. The objective of the …… analysis is to arrange the departments in such a manner that the transportation costs of material handling are minimized.
7. The …… method also follows the same basic idea as the 'Travel Chart Technique', but with some operational differences.

11.4 Product or Line Layout

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. 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.

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.

Advantages of Product Layout

The product layout has various benefits. It facilitates the effectiveness and efficiency in production. Less work in process (WIP) inventory is required in case of product layout, as the flow of material is continuous along a line. Compared to process layout, product layout requires less space for same volume of production.

In product layout Conveyorized material handling or automation in the material handling is cost effective, as the flow of material is well known. The throughput time (or product cycle time) is not as much of as compared to process layout. This is because of fewer chances of congestion and less waiting time on machine.

In the product layout, Simple production planning and control and better coordination of different activities may be achieved. The skill level of workers possibly will be lesser, as a particular

worker has to do a particular operation, which hardly ever changes due to standardized production line. In product layout the flow of material is smooth and continuous.

The various advantages of product layout are summarized below in the following points:

1. Capital costs spread over many units
2. Narrow tasks reduce training costs
3. Allows wide span of supervision
4. Low material handling costs
5. Routing and scheduling is automatic
6. High labor and equipment utilization
7. Accounting, purchasing, inventory control are fairly routine

Notes **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 more about assembly line balancing. Find more information about the evolution of this concept.

Self Assessment

Fill in the blanks:

8. Product layout is used for …… operations, where the part variety is less, production volume is high and part demand is relatively stable.
9. The assembly line concept is applicable on products that can be produced with …… parts.

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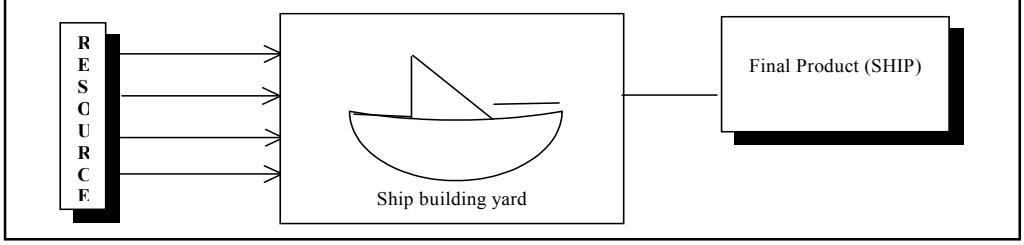
11.5 Fixed Layout

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.

Examples: Production of aircraft, ships, dams, bridges, and housing industry.

Figure 11.6: 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.

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.

Self Assessment

Fill in the blanks:

10. In fixed layout, the …… remains at a fixed position.
11. Need for Fixed Position of layouts arises in case of …… products.

11.6 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.

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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.
3. Analysis of the production flow of items (for grouping items according to manufacturing process similarities).

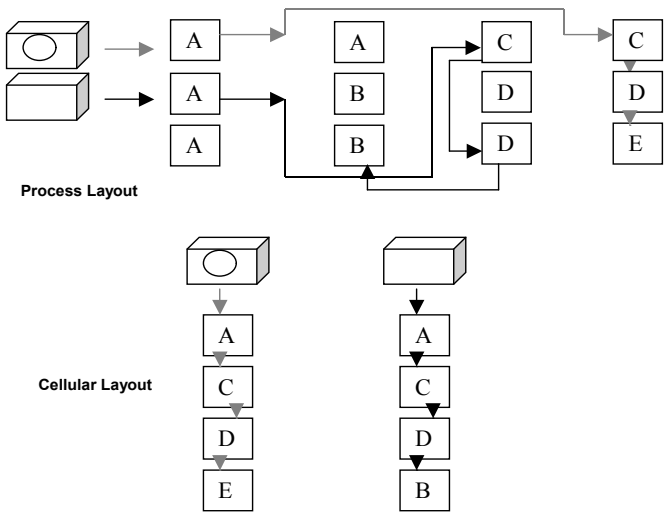
This identification and coding is the chart of group technology. The equipment to make these is grouped together and designated for these parts. To some extent, a process layout, characteristic of job shops, is changed to a small well-defined product layout. This group of equipment is called a cell, and the arrangement of cells is called a Cellular Layout.

Figure below 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 11.7: Process Versus Cellular Layouts



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Caution 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.

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.

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.

Notes 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.

The U-shaped assembly line: 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.

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 'overproduction'. 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,

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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:

- Reduced manufacturing flexibility.
- 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).
- 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.
- There is increased operator responsibility, and therefore behavioural aspects of management become crucial.

Self Assessment

Fill in the blanks:

12. Group layout is suitable when a large variety of products are needed in ……volumes.
13. In the Cellular Layout, the machines are grouped in a …… .

11.7 Application in Service Industry and Comparison of Layouts

Services establishments for instance motels, hotels, restaurants, must give due attention to client convenience, quality of service, efficiency in delivering services and gratifying office ambience. In today's environment, the clients look for easiness in approaching different departments of a service organization and therefore the layout should be designed in a fashion, which allows clients quick and convenient access to the facilities presented by a service establishment.

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 workstations, 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 workstation 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 workstations, is used by the Japanese, to allow workers to help a fellow worker catch up, thus increasing teamwork among workers.

Plant layout is as well applicable to five star hotels as well. Here lodging, bar, restaurant, kitchen, stores, swimming pool, laundry, shaving saloons, shopping arcades, conference hall, parking areas etc. should all find an appropriate place in the layout. Here significance must be given to cleanliness, elegant appearance, convenience and compact looks, which magnetize customers.

Did u know? Plant layout is applicable to a cinema hall, where emphasis is on comfort, and convenience of the cinemagoers. The projector, screen, sound box, fire fighting equipment, ambience etc. should be of greatest importance.

Notes

Comparison of Layouts

We have seen that both product and process layouts have their advantages and disadvantages. Product layout is desirable by most organizations, even if the low volume and the variety of their products does not warrant it. Therefore, they have no choice but to go in for good old batch processing on process layout.

Product layout and process layout represent the two extremes of layout techniques. Cellular layout had evolved to aid manufacturers with intermittent manufacturing of a high variety of products with the advantages of a product layout.

Table 11.3: Comparison of Common Characteristics of different Layouts

Factors	Fixed position	Product (Line)	Process (Functional)	Cellular (GT)
Product	Made to Order, Low Volume	Standardized Product, Large Volume, Stable Rate of Output	Diversified Products using common operations, Varying volumes, Varying Rate of Output	Diversified Products, Varying volumes,
Process	Ship building, large scale project, construction or industrial project	Continuous, and repetitive	Job or small batch	Small to medium batch
Arrangement of facilities	Facilities move where the fixed product/project is being implemented	Placed along the line of product flow in a specialized sequence of tasks for each unit	Grouped by speciality and by function	Similar parts are grouped in part-family; one machines cell is formed which contains all facilities needed by corresponding part-family
Cost of layout	General purpose equipment. Moderate to low	Large investment in specialized equipment and processes.	General purpose equipment and processes. Moderate to high	Moderate to low
Inventory	Variable inventories and frequent tie-ups because production cycle is generally long.	High turnover of raw material and work in process	Low turnover of raw material and work in process, High raw material inventory	High turnover of raw material and lower work in process
Material handling	Flow variable, often low. May require heavy duty handling equipment	Predictable, flow systemized and often automated	Flow variable, handling often duplicated	Flow variable, can be reasonably high
Material travel	Variable path	Fixed path	Often high	Fixed path
Utilization of facilities	Moderate	Very high	General purpose	High
Operating facilities	General purpose	Special purpose	Skilled	Special purpose
Employee skill	Unskilled/skilled	Unskilled	Skilled	Multi-skilled as one operator may handle more than one operation
Quality/Product Variety Ratio	Normally 1, as single product production	Large (Q/P)	Moderate (Q/P)	Small (Q/P)

Self Assessment

Notes

Fill in the blanks:

14. …… and …… layout represent the two extremes of layout techniques.

15. …… layout had evolved to aid manufacturers with intermittent manufacturing of a high variety of products with the advantages of a product layout.

11.8 Summary

- Facility planning involves decisions about the functional layout and physical arrangement of economic activity centers.
- Every layout has four fundamental elements which are Planning Units (SPUs), Affinities, Space and Constraints.
- The four basic types of layouts are Process layout, Product 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.
- A number of computerized layout programs have been developed since the 1970s to help devise good process layouts.
- 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.
- Fixed Position Layout is essential when the products are difficult to move.
- Cellular or group layout is suitable when a large variety of products are needed in small volumes.
- Plant layout is as well applicable to five star hotels and to a cinema hall, where emphasis is on comfort, and convenience.
- Product layout and process layout represent the two extremes of layout techniques.

11.9 Keywords

A Fixed Layout: It is a layout where the material remains at a fixed position and tools, machinery and men are brought to the location of the material.

A Product 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.

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.

Computerized Relative Allocation of Facilities Technique (CRAFT): A method uses a load matrix, distance matrix, and cost per unit distance traveled as initial inputs and then tries to improve the relative placement of the departments as measured by total material handling cost for the layout.

Facility Planning: It offers real added value improvements to the organization's core business at four levels; Site Location, Site Planning, Facility and Building Layout and Workstation Design.

Notes

Process layout: It is also known as functional layout. Similar machines or similar operations are located at one place as per the functions.

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?

11.10 Review Questions

1. Compare and contrast the process and product layouts. Give figures and tables to explain the points.
2. Link capacity and layout. How important it is to consider the capacity of the firm while designing a layout?
3. Under what conditions does fixed layout work well?
4. With the help of examples, explain the concepts of mixed line layout and retail layouts.
5. Why it is not advisable to have fixed layout for firms producing small size products?
6. 'Product layout and process layout represent the two extremes of layout techniques.' Justify the statement with suitable examples.
7. Cellular layout had evolved to aid manufacturers with intermittent manufacturing of a high variety of products with the advantages of a product layout.' Explain
8. Discuss the similarities and differences in the objectives of the layout for a continuous flow process and a batch process.
9. Flexible manufacturing systems try to produce products with large variability on the same set of equipment with minimal set up times. How does cellular manufacturing help in this process?
10. For which kind of organizations cellular or group layout is suitable?

Notes

Answers: Self Assessment

1.	functional	2.	Intermittent
3.	competitive	4.	materials
5.	functional	6.	spiral
7.	CRAFT	8.	continuous
9.	identical	10.	material
11.	extremely large	12.	small
13.	line flow	14.	Product, process
15.	Cellular		

11.11 Further Readings

Books

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Notes

Unit 12: Facility Location

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Objectives

After studying this unit, you will be able to:

- Describe the need and nature of facility location;
- Explain the factors affecting location selection;
- Discuss the procedures for location decisions.

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.

Notes

12.1 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.

Self Assessment

Fill in the blanks:

1. The development of a location strategy depends upon the …… of firm being considered.
2. The objective of location strategy is to …… the benefit of location to the firm.

12.2 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 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.

Notes

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.

Examples: 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 railroads 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.

Examples: 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.

Notes

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.

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.

Notes

Table 12.1: 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

Self Assessment

Fill in the blanks:

3. Location is a critical element in determining…….. and……. costs for both industrial and service firms.
4. Heavy manufacturing facilities are primarily plants that are relatively large and require a lot of space and as a result, are …… to construct.
5. The single most important factor for locating a service or retail facility is ……to customers.

12.3 Factors Affecting Location Decisions

12.3.1 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.

Notes

(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.

Notes

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, 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.

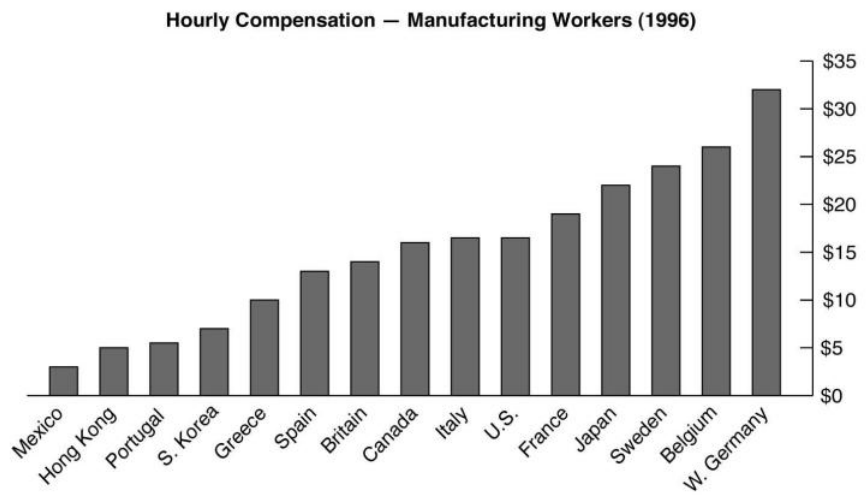
(a) Skills available – size of the labour force – productivity levels.

(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**



Notes

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 below 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 12.2: 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.

Notes

Caution 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.

12.3.2 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.

Self Assessment

Fill in the blanks:

6. Assembly-type industries, in which raw materials are gathered together from diverse locations and are assembled into a single unit, often tend to be located near the …… .
7. Adequate transportation facilities are essential for the …… operation of a production system.
8. For companies that involved in import and export activities, location of …… is a factor of prime importance in the plant location decision.

Notes

12.4 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.

12.4.1 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.

12.4.2 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

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

12.4.3 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.

Self Assessment

Fill in the blanks:

9. When the site selection process is initiated, the pool of potential locations for a manufacturing facility is……...

Notes

10. In India the Western and Central regions are generally most preferable and the Eastern region is least preferable for …… facilities.

12.5 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.

12.5.1 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.

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

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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.

12.5.2 Impact Planning

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

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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

For 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

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in domestic tank for drinking purpose. Limited rooftop 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.

Did u know? Low temperature has to be maintained in the garbage room for reducing decomposition and thereby foul smell.

12.5.3 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.

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.

   Caution 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.

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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.

(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.

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.

Self Assessment

Fill in the blanks:

11. The master planning team's work is broadly divided into ……phases.

Notes

12. Any facility will create an impact on the environment, this is called ……..footprint.
13. ……should be the step after the facility impact assessment bears out the suitability of the site.
14. Site evaluation should be the step after the ……. bears out the suitability of the site.
15. The site selection process eventually narrows down to the determination of the best location within a …….

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

Contd...

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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.
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?

Source: Upendra Kachru, Production and Operations Management – Text and Cases, First Edition, Excel Books, New Delhi 2007.

12.6 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.

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- 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.

12.7 Keywords

Ecological Footprints: The impact of the facility on the environment.

Facility Master Plan: It helps plan the right services consistent with firm's mission.

Facility Planning: Planning providing physical capability to add value to the organisation.

Heavy Industries: Plants that are relatively large and require a lot of space.

Impact Planning: The integration of commercial and practical environmental objectives to produce optimum benefits for business and environment.

12.8 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?
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?

Notes

Answers: Self Assessment

1. type
2. maximize
3. fixed, variable
4. expensive
5. proximity
6. intended market
7. economic
8. ports
9. global
10. manufacturing
11. two
12. ecological
13. Site evaluation
14. facility impact assessment
15. community

12.9 Further Readings

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Unit 13: Production Planning and Control

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Objectives

After studying this unit, you will be able to:

- Recognize the concept of production planning and control;
- Define aggregate and material requirement planning;
- Discuss the importance of time horizons and dovetailing of plans.

Introduction

The conversion of a customer's order to a finished product needs generally the organisation and planning of the manufacturing process. The overall objective of any organisation is to improve

its profitability through productivity i.e. by employing various inputs (Men, Machines, Materials, Money & Management) effectively so as to bring about the desired manufacturing results in terms of quality, time and place.

13.1 Production Planning and Control Defined

Production Management is concerned with basically the two important functions of Production:

1. Production Planning
2. Production Control

Production Planning: It is concerned with the planning of various inputs (Men, Machines, Materials etc.) for a given period of time so that the customer could get the right quality of products at right place, price and in time.

Notes Production Planning may be done as:

(a) Long Term Planning: Strategic Planning – normally more than an year's time.

(b) Medium Term Planning: Aggregate Planning – up to an year's time.

(c) Short Term Planning: Routine Planning – monthly/weekly.

Production Control: It measures the actual performance of the production units and taking remedial action called for to see that the production actually achieved is not less than the target or standard set in advance.

Caution Production Planning alone is not sufficient to achieve the objective of any organisation.

Thus Production Planning and Control is to set the realisation targets in terms of Standard Output, measure the actual production performance against the target set in advance and take remedial action as and when necessary.

13.1.1 Main Functions of Production Planning and Control

Following are the main functions performed by a PPC department:

1. ***Order Preparation:*** Once an order, through the sales department, is received for execution, activities like preparation of the work-order, converting the same into shop-order and then releasing the same to various departments for planning action at their end for their concerned activities get started.
2. ***Materials Planning:*** Material Requirement Planning (MRP) is based on the orders on hand, the inventory position of the finished goods & raw materials; the expected demand from marketing/sales department, the capacity of various production shops and bills of materials, the lead time and constantly following up of the status with purchase and stores departments against specific shop orders is done.
3. ***Routing (or Process Planning):*** Process Planning means fixing the process of manufacturing/sequence of operations, the tools, and fixtures required and also the

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measuring instrument and gauges for inspection/quality control so as to produce the right quality of products at the most economical cost and for delivering the product timely to a buyer.

Did u know? A well equipped PPC department also works out for their periodical replenishment of worn-out tools, etc.

4. ***Scheduling:*** Scheduling of manufacturing order takes care of the following:
   (a) Preparation of machine loads.
   (b) Fixation of calendar dates of various operations/sequence of operations to be performed on the jobs & follow-up the same.
   (c) Coordination with sales to confirm delivery dates of new items and keeping them informed about the periodical despatch schedules.
5. ***Dispatching:*** Dispatching concerns preparation and distribution of show orders and manufacturing instructions to the concerned departments. The instruments and show orders received by various departments is an authority for them to perform the work according to that schedule.
6. ***Progressing:*** Progressing means control, i.e., collection of data from various manufacturing shops, recording the progress of work and comparing progress against the plan.
7. ***Expediting:*** Expediting means chasing intensively the bottle neck areas causing delays/ interruptions in carrying out smooth production and taking appropriate actions from time to time and keeping the concerned authorities well informed about the progress of planned targets. Also to communicate the sales department promptly about the failure in delivering commitments, if any.
8. ***Miscellaneous Functions:*** In addition to above usual functions of PPC, they are also helping in cost estimation, fixation of standards through Industrial Engg., capacity planning, make or buy decisions, projection of companies' product market on long terms basis.

Self Assessment

Fill in the blanks:

1. …… measures the actual performance and taking remedial action to see that the production actually achieved is not less than the target or standard set in advance.
2. …… is concerned with the planning of various inputs for a given period of time.

13.2 Production Planning Problems in Job Shop Production and Continuous (Mass Products) Systems

As described above Production Planning is concerned with determining what products are to be produced, in what quantities and when. It also considers the resources required to accomplish the plan. And Production Control determines whether the resources to execute the plan have been provided and if not, takes the necessary action to correct the deficiency.

Problems in Production Planning and Control for different types of manufacturing systems depend upon the following factors:

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(a) ***Product Variety and Production Quantity***

Logistic Problems:

For Job Shop Production (an intermittent Process):

In this case, many different types of products are made and each product is made in low quantities. The products are often complex, consisting of many components each of which must be processed through multiple operations.

Solving the logistics problems in such a plant requires detailed planning scheduling and coordinating of large numbers of different components and processing steps for many different products.

Whereas for mass production (Continuous Products Process), in which a single or more products are made in large quantities.

Did u know? The logistics problems in Mass Production are simple if the products are simple and for large component in case of an assembly line of automobiles or household appliances and the facility is organised as a product line.

The logistic problem in operating such a case to get each component to be at right workstation at the right time so that it can be assembled to the product as it passes through the station.

(b) ***Planning Function:*** To distinguish between these two extremes in terms of the issues in production planning and control, we can say that the Planning function is emphasised in a job shop, whereas the control function is emphasised in the mass production of assembled products. There are many variations between these extremes, with accompanying differences in the way production planning and control are implemented.

Task Find out the similarities and dissimilarities between the production planning system of a car manufacturing company and a FMCG company.

Self Assessment

Fill in the blanks:

3. Planning function is emphasized in a job shop, whereas the control function is emphasized in the …… of assembled products.
4. Solving the logistics problems in job shop production plant requires detailed planning scheduling and coordinating of large numbers of …… components.

13.3 Aggregate Planning Defined

Aggregate Planning may be defined as 'Intermediate Planning' which is normally done for a period of up to one year's time. The word 'Aggregate' symbolises that the planning is done at the broadest level. The details of the individual product requirements and the detailed scheduling of various resources (men/machines) and other facilities is normally not done and left to the individual at lower level to carry out the same.

Notes

13.3.1 Various Steps Involved in Aggregate Planning

1. The first step involved is the forecast of resource for a reasonable period (normally up to a year's time).
2. The state of the system at the end of last period.
3. Once these two factors are decided, the decision for the upcoming period about the size of the workforce and production rate can be known.
4. Also, the decision made may call for having or laying of personnel thereby expanding or contracting the effective capacity of the productive system.
5. Special techniques available for Aggregate Planning are:
   (a) Graphical Method
   (b) Linear Decision Rule (LDR)

Objectives of Aggregate Planning are:

1. To make use of the available facilities and resources to ensure their optimum use.
2. Aggregate Planning increases the range of alterations for capacity use through various techniques viz., hiring of additive manpower or laying out of personnel thereby fixing the size of the workforce and the production rate.
3. Inventories for work-in-progress and finished goods is made during the loan demand so as to use the same to meet the peak demand.
4. More time is devoted to produce more from the same machinery capacity through properly employing the sequencing and scheduling techniques.
5. The following variables are studied under the Aggregate Planning:
   (a) Production Rate
   (b) Labour Employment
   (c) Inventories
   (d) Sub-contracting (if permissible)

If the production rate and labour employment are fixed, the Inventories & Sub-Contracting can be derived therefrom. However, Aggregate Planning is not long term planning.

Box 13.1: Conversion of an Aggregate Plan into a Master Schedule

Month	Apr.	May	Jun.	Jul.	Aug.	Sept.
UNITS REQD.	4000	3000	5000	5000	6000	3000
MONTH	Oct	Nov	Dec	Jan	Feb	Mar
UNITS REQD.	3000	4000	5000	6000	5000	4000

Notes

Box 13.2: Master Schedule

Month Rating	Apr.	May	Jun.	Jul.	Aug.	Sept.
6A	2000	2000	3000	3000	4000	2000
16A	1200	500	1000	1000	1000	-
20A	-	200	-	500	-	-
25A	-	-	500	-	500	500
32A	500	-	500	200	200	200
40A	200	-	-	200	200	200
63A	100	-	500	100	100	100
	4000	3000	5000	5000	6000	3000
Month Rating	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
6A	2000	3000	4000	4000	3000	3000
16A	500	500	-	500	500	500
20A	500	-	500	500	500	-
25A	-	500	500	500	500	500
32A	-	-	-	200	200	-
40A	-	-	-	200	200	-
63A	-	-	-	100	100	-
	3000	4000	5000	6000	5000	4000

13.3.2 Various Strategies Involved in Aggregate Planning

The objective of the various strategies of Aggregate Planning is to smooth out the peaks and voltages of the demand during the Planning horizon. This is achieved through actions briefed below:

1. Without changing production output rate.
2. Varying production output rate.
3. Appropriate Inventory Level.
4. Subcontracting.
5. Capacity Utilisation.

1. ***Without Changing Production Level***

   (a) During periods of low demand, the increase of sales of goods can be done through special discount schemes/cutting prices etc.

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(b) During periods of high demand, the method of back logging orders can be adopted but depends upon the willingness of the customer if he could wait for that much time. However, backlogging of orders is not without danger of loosing goodwill.

2. ***Change in Production Level***: The change in production level is done to the extent possible to contain the fluctuation in demand. This is achieved as follows:

   (a) When demand is on the increasing side, the output rate can be changed by hiring workers temporarily. Wherever, it is possible to increase production through change in workforce or by keeping workers on overtime (OT) or through some special Incentive Schemes/by altering the capacity through increase of a few equipments/machinery or sometimes by changing the planned plant shut downs.

   (b) When demand is decreasing, changing the output rate by logging off Casual/Temporary Workers/by paying full salary to employees but reducing output rate for a short period – Without demoralising/demotivating the workforce or by reducing capacity by switching off part machinery whenever possible.

3. ***By Appropriate Inventory Level***: Inventory of furnished goods is increased during periods of low demand and the same can be used to meet high demand/seasonal demand in other periods. Manufacturing firms can use this strategy very well.

4. ***Sub Contracting***: Sub contracting means meeting demand through acquiring part of goods from other manufacturers/producers rather than making in-house. House benefits must be weighed against cost and quantity.

5. ***Capacity Utilisation***: Capacity Utilisation is very common to service industries, organisations or companies which cannot store products or services. They must arrange to meet peak load through sharing capacity utilizations.

Examples: Telephone Companies, Electric Power Companies & Computer Time Sharing Companies.

Self Assessment

Fill in the blanks:

5. The first step involved in aggregate planning is the ……of resource for a reasonable period.

6. ……..means meeting demand through acquiring part of goods from other manufacturers/producers rather than making in-house.

7. Special techniques available for Aggregate Planning are ……..Method and Linear Decision Rule.

13.4 Material Requirement Planning

13.4.1 Material Planning

Material Planning is a technique of determining the requirements of raw materials, components, spares etc., required for the manufacturing of the product. If the delivery date of the finished product is known in advance, then the ordering time and quantity of other work-in-progress can

Notes

be planned accurately with the help of mathematical calculations. This planning of work-in-progress of the finished goods is known as Material Requirement Planning (or MRP).

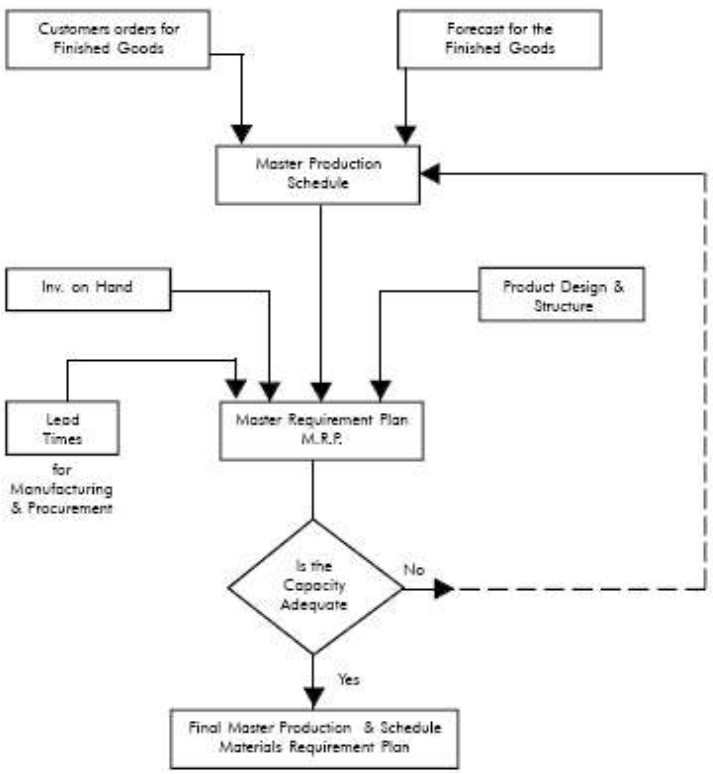
Notes While doing Material Requirement Planning one has to look for the following things:

1. All the components, sub-assemblies and assemblies are known so that they all can participate for the planning of required materials.
2. The lead time of all the assemblies and sub-assemblies should be known.
3. The inventory already in hand should be considered for the present Material Requirement Planning.

13.4.2 The MRP Process

The MRP process is initiated once the customer orders for the finished goods from the supplier. Then the forecasting is done for the finished goods. A master plan is prepared for the production process. This master plan contains all the constituents of the production process that would finally lead to the resultant product.

Figure 13.1



The master plan for production initiates the process of Material Requirement Planning. For MRP two other inputs are inventory which is already in hand and product design and development. Then we have to see whether the capacity is adequate for the production of requisite number of finished goods demanded by the customer. If the answer is negative, then again we have to reschedule our production plan. But if the answer is affirmative i.e., there is

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adequate capacity then we can go for the final master plan that would ultimately lead us to the Material Requirement Planning.

The MRP can be understood with the help of following (Figure 13.1).

13.4.3 Benefits of MRP System

As shown in the Figure 13.1, it is clear that the MRP system is very much commendable to computerisation. Hence for very large number of products e.g., for many assembled products, perhaps with sub-assemblies, the number of parts involved can easily be in thousands. Requirement generation, inventory control, time phased orders and capacity requirements, all have to be coordinated. All this can be done in a relatively straight forward manner. Thus practically all advantages of computerised planning can be thought of with MRP system e.g., change in production schedule due to change in market demand, cancellation of orders, change in procurement policy, delays in receipt of incoming materials and also the change in capacity planning etc., all this may reduce idle time at various stages and hence may increase productivity by men, machine & materials.

Self Assessment

Fill in the blanks:

8. ……..is a technique of determining the requirements of raw materials, components, spares etc., required for the manufacturing of the product.
9. If the delivery date of finished product is known in advance, then ……time and quantity of other work-in-progress can be planned accurately with the help of mathematical calculations.
10. The ……contains all the constituents of the production process that would finally lead to the resultant product.

13.5 Timing Decision

An industry is a methodical economic activity. It produces physical products or services. Jobs have to be planned. Time schedules for these jobs or for tasks within an assignment are essential. This is uncomplicated to understand. The role of operations planning and scheduling is, therefore, clear. While the time 'craft' became an 'industry' businessmen have understood the function of planning/scheduling production/operations. In fact, one may argue that those nations/ peoples that deliberately cared for time industrialized faster. Those nations that believed in a lax or relaxed notion of time may have had crafts but these industrialized rather slowly. Thus 'time' has been linked with industry.

Caution Without the schedules there will be chaos

Though, the focus on time in the early half of the twentieth century-the century of worldwide industrialization- had been about bringing order into the otherwise chaos. It was concerning making one's own life a little easier. There was this demand function for the products that required to be addressed to. In a job-shop environment, the by now given promises had to be met. This involved some planning and numerous short term decisions or firefighting. Production had to be planned and then the deviations (which were ordinary) had to be controlled. Time was something that a market demanded or an individual customer requests for. Time was a constraint.

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For a long time it was all uncomplicated and straight-jacketed. Production/operations had to have a long-range plan- a plan of activities for say 5 to 10 years. This plan had to be brought down to the controllable yearly, and then quarterly or monthly plans. This would help in wide allocation of facilities. This was the intermediate range plan or aggregate plan. Then, foundational on these plans, the weekly/daily work schedules had to be made-as to which particular machine and which person will work on which exacting job. This planning was and is good. It is necessary to plan future work so that the demand and available capacity can be matched. Work has to be prearranged in terms of the long term future (mostly forecasted) requirements on the production or operations facility, the intermediate term real loads on it and the definite production in the short term. This line of thinking is valid even today. However, one needs to understand that this is only one dimension of time. It is a view that treats time as a constraint posed by the market. It is a quantitative outlook.

13.5.1 Importance of Time-Horizon

Plans have a time dimension and to the extent the time-span is restricted, the scope of functional plans also remains limited with less interaction from further functional plans. The longer the time span of the plan, the more integrative, organisation-wide the plan has to be. The wider time prospect plans cover a wider organisational perspective. That is why very frequently the corporate planning process is identical with long-range planning.

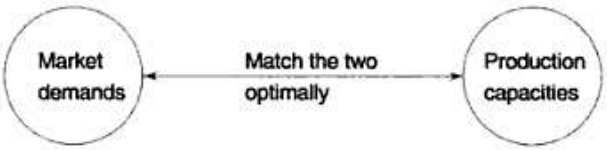
Since the time horizon of the production plan widens, from a short range plan (day to day scheduling), to a middle range (monthly, or quarterly or annual), to a long range plan (annual or five-yearly), the elasticity available- to change the variables and allow modifications when found necessary-also increases. The five year range plan allows a corporation the flexibility of increasing the production capacity by purchasing fresh equipment, locating new plants, acquiring new technology, or recruiting adequate technical manpower.

This is not applicable for a one year plan. Here much of the flexibility in procuring latest plants and machinery or acquiring the technology or know-how is lost. Approaching to the weekly or daily plans, hardly any flexibility is left apart from to assign different jobs to the available machines and manpower. As the flexibility lessens the strategic or tactical options also decrease and the nature of planning itself assumes a different character. The planning problem for diverse time horizons are therefore different and the solutions are too different.

13.5.2 Dovetailing of Plans

One significant fact is that the short, medium and long-range plans have to dovetail into one another. Shorter range plans are for all time made within the framework of the longer range plans. Production planning as it is usually understood is really the intermediate-range and short range plan. The long range production plan has lost its individuality with the overall corporate planning process. That is why, production planning is said to go after from the marketing plan. Or, as is usually said, the production plan is the paraphrase of the market demands into production orders. The market demand has to be coordinated with the production capacities.

Figure 13.2: Production Planning



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The keyword in figure is 'optimally'. Market demands are moreover known or are forecasted, but we do know them, and the production capacities are also recognized. But how these two are matched will produce different cost structures and utility (e.g. time) structures. Optimization of the cost or other utilities is the anxiety of production planning.

The market demands (actual and forecasted) will not typically be level and steady over time. At different points of time the market will demand differently. It is, not for all time possible for the production department to chase the market fluctuations as and when they arise (or even if they are known in advance) and very frequently it is not 'optimal' (economical cost wise) to do so. Therefore, the production plan will many a time, look very dissimilar from the marketing or sales plan, although the total production figures will be more or less in agreement by way of the market requirements.

Self Assessment

Fill in the blanks:

11. Production planning as it is usually understood is really the ……and …… range plan.
12. It is necessary to plan future work so that the …… and available capacity can be matched.

Caselet

Reliance Industries Ltd.

Reliance Industries Ltd. (RIL) has emerged as the largest private sector company in the country. It has grown at a Compound Annual Growth Rate (CAGR) of over 26 per cent in the last 25 years. It's sales income increased at a CAGR of 26.61 per cent from 1976-77 to 2001-02. Net profit soared over 2200 times or at a CAGR of 36.05 per cent. Reliance's total assets shot up from ₹ 328.90 million in 1976-77 to ₹ 298,750 million in 2000-01. It's net worth moved up from ₹ 95.40 million to Rs. 147,650 million in this period. From a tiny market capitalization of ₹ 780 million in 1979-80, Reliance's market cap jumped to ₹ 298,700 million in 2000-01.

RIL was built on a step-by-step process of backward integration from textiles and fibers to fiber intermediates and feedstocks and, finally, all the way to oil refining and exploration. The company used its proven competencies in mobilizing large amounts of capital, in creating large new markets and in managing mega-projects to attain its position in the Indian business world.

In 1981, RIL secured a licence for manufacturing 10,000 Mega Tonnes (MT) of Polyester Fibre Yarn (PFY) and obtained technology from DuPont for setting up the facility. For installing this facility, the company acquired a massive 300-acre plot of land in Patalganga, near Mumbai. In implementing this project, the company adopted three strategies that it has since repeated over and again to drive its phenomenal growth.

First, the size of Reliance's facility represented "world scale" capacity that would meet the cost and quality standards on a global basis. This was a major departure from the normal practice of the time of creating a "safe" capacity based on reasonable projection of demand. Dhirubhai Ambani, the founder of RIL, created capacity ahead of actual demand and on the basis of the latent demand. Then, he would go about systematically removing the barriers that were constraining the demand.

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The second element of the strategy was to purchase technology from the best foreign source rather than to create joint ventures. Conventional wisdom, at that time, believed in joint ventures for capacity expansion but RIL had a belief that joint ventures slowed everything down and hence they kept away from them.

The third element of the strategy was speed. RIL considered the cost of time to be critical and did everything to compress time in both their projects. For instance, RIL set up it's worsted spinning plant within eight months of grant of the licence. However, for the PFY plant, it got it ready in fourteen months—even surprising its collaborators, DuPont. For example, RIL laid scores of kilometers of pipes in readiness for the equipment to arrive and to be installed as soon as it landed, instead of linking the various pieces of the equipment after receipt. By 1983, PFY was the major revenue earner in RIL's portfolio. It maintained this position by continuously modernizing and expanding its PFY capacity.

This was a strategy the company would follow for all it's businesses. It would also continuously modernize and increase capacity to mop up all incremental market growth to build a position of absolute industry leadership. This continuing capacity growth gave it other advantages also; for example, it allowed the company to emerge as the lowest cost polyester producer in the world. Beyond the cost advantage, RIL used capacity as the company's key instrument for enhancing customer service.

In 1984, RIL sought to further expand its Polyester portfolio. It obtained a licence for manufacturing 5,000 MT of Polyester Staple Fiber (PSF). In addition to expanding its Polyester portfolio, RIL sought to further backward integrate its operations. It obtained licences to manufacture fiber intermediates—Purified Terephthalic Acid (PTA) and Mono Ethylene Gycol (MEG). RIL had started manufacturing polyester from Dimethyl Terephthalate (DMT)—an alternate raw material for PTA. It also obtained the licence to manufacture 50,000 m. tones of Linear Alkyl Benzene (LAB), an intermediate for the production of detergents market, triggered by the success of Nirma, a new low-cost brand. Throughout, RIL obtained sanctions for capacities, which were far in excess of it's needs of these products for captive consumption.

RIL, in keeping with it's strategy of continuous investment in additional capacity, expanded it's capacities in each of these businesses. In fact, in a number of cases it expanded the capacities even as it was installing the originally sanctioned smaller capacities. Further in each of these businesses, RIL achieved a level of capacity utilization that was far higher than that of most competitors.

RIL also started to use this capacity to expand its markets. It not only used it's scale to advantage, but also upgraded it's quality to export a major part of the output. It marketed products both under its own name and through well established international companies like DuPont. To support exports, the company set up Reliance Europe Limited, a wholly owned subsidiary in London. The improvement in quality necessary for export together with it's experience with international customers was used by RIL to reinforce the company's competitive advantage at home.

Beyond export, the company also pursued an aggressive strategy of demand creation at home. It created special development groups to find applications that would use RIL products as feedstock. It provided such services free of cost to potential investors in these product areas and also used it's own network to help these investors secure both funding and distribution. As a result of such "demand-creation-activities" at home and abroad, RIL was able to achieve 100 per cent capacity utilization in PSF, for example, while most of its competitors did not achieve more than 50 per cent capacity utilization.

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Between 1989 and 1992, RIL further backward integrated it's operations. It set up facilities to manufacture LAB directly from kerosene with n-paraffin as intermediate raw material. It also commissioned the facilities for the manufacture of paraxylene (input material for manufacturing PTA). Both these facilities were set up at it's Patalganga complex. At it's Hazira complex, it set up an ethylene cracker complex, and commenced manufacturing MEG, PE, ethylene dichloride (a feed stock for manufacturing PVC) and PVC. It also planned a world scale caustic soda chlorine facility to produce chlorine for meeting it's own captive needs for the manufacture of ethylene dichloride, and also for sale in the local market.

In order to expand its activities at Hazira, in 1992, RIL sponsored Reliance Polypropylene Ltd. and Reliance Polyethylene Ltd., both joint ventures with C. Itochu, Japan. These companies were to manufacture 250,000 MT of polypropylene and 160,000 MT of polyethylene respectively. They mobilized over Rs. 6 billion from the capital market in November 1992 to part finance the projects which were expected to go on stream by the end of 1994.

During 1991-2, RIL secured a licence to set up a 9 MT refinery. It subsequently promoted a new company, Reliance Petroleum Limited, in which it had a 21 per cent stake, for setting up the refinery which would meet it's feed stock requirements of naphtha for the manufacture of paraxylene (PX) and kerosene for the manufacture of LAB. Due to regulatory restrictions to market petroleum products directly, the new company entered into a marketing and distribution arrangement with the state-owned Bharat Petroleum Corporation Limited (BPCL), the third largest integrated refining and marketing oil company for marketing the products of the refinery. However, when the restrictions were removed, RIL started to set up it's own outlets throughout the country. In 1994, RIL completed it's vertical integration chain by entering into oil and gas exploration. It has since announced a number of gas strikes on the east coast.

In addition to vertically integrating it's operations, RIL also expanded it's existing businesses, in each of which it had already achieved positions of absolute leadership in the domestic market. It was now in the process of setting up new capacity to manufacture 120,000 MT of PFY, 100,000 MT of PSF 80,000 MT of PET and 350,000 MT of PTA. This complex at Hazira is planned to be bigger than their polyester complex at Patalganga. On completion, the total polyester capacity of RIL would be over 500,000 MT and that would make them the No.1 integrated producer in the world.

According to Dhirubhai Ambani, "By operating as if the environment was deregulated, we have a head start. But others are catching up. On the Indian side, the visibility and success of Reliance has made others develop the courage to think big. The Reliance formula is no longer a secret. Also, they will not have the impediments we had. They will be on tested grounds. More importantly, they will be able to benchmark themselves against us. At the same time, there is also a big change in the global companies. Earlier, they were not very interested in India—the country did not have credibility. Now they see India as a major growth opportunity. So, they will provide a driving force. They will push their technology… they will educate our domestic competitors."

According to RIL assessment, this area still offered almost unlimited opportunities for further growth. In order to justify entering into a new area of opportunity, it was essential that it must provide opportunities for the kind of Return on Assets and growth performance that Reliance had come to expect. The benefits of focus are obvious, yet to a group that is in hurry and has a management team accustomed to achieving the impossible, the new opportunities are almost too attractive to resist.

Source: Upendra Kachru, Production and Operations Management – Text and Cases, First Edition, Excel Books, New Delhi 2007.

Notes

13.6 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.

How this is achieved can be best understood with an example.

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 despatch.

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 13.1 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 the Table we know that:

1. The task assigned to station 1 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.

Notes

Table 13.1: 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	

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.

Notes

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.

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 13.1, 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 above. TAMS decided to balance the assembly line.

13.6.1 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.

Caution 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 above – 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.

Notes

Example: The contact breaker facility, we have already taken the first step, defining tasks, shown in Table above The second step requires identifying a specific sequence. These sequence requirements are also listed in Table 13.1 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 above 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 above 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 13.1 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 workstation. 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 below, 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.

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Heuristic Steps 5-7: Repeat the above-explained process to get Table below. Note that we have used five workstations for the assignment of all the tasks. It could have been more.

Practical Example 1

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 13.2, showing a five-station assembly line comprising 10 tasks.

Table 13.2: 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. B: Install contacts C: Install Springs D: Install plastic levers etc. on Molding Half.	None A B A,C A	0.010 0.020 0.020 0.040	1
2	1	H: Close with other Molding Half I: Assemble 4 of the above units J: Insert Rivets	G H I	0.050 0.008 0.040	1
3	2	K: Rivet the sandwich units	J	0.098	1
4	3	L: Switching Test under load	E	0.050	1
5	4	M: Pack Contact Breaker unit	F	0.020	1
	Total			0. 354	

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.

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 13.2. Finally, if the desired output does not exceed the required capacity, bottlenecks may be reexamined.

Notes

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 tonne 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 multi-lane 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.

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 13.3.

Table 13.3: Final Assembly Line Design

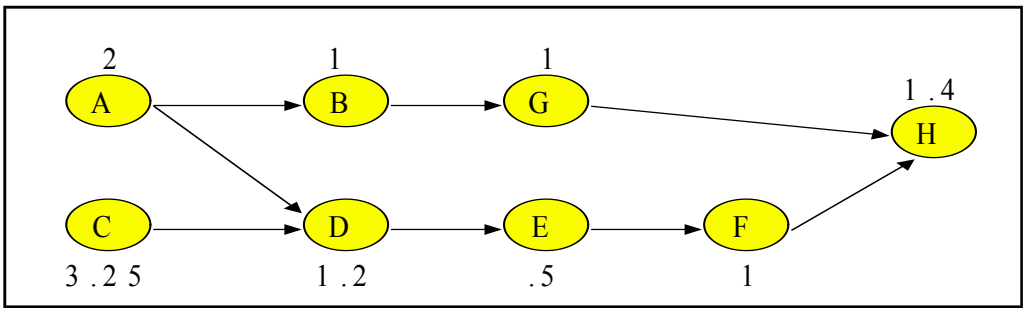
Work Station	Preceding Work Station	Task Assigned	Predecessor Task	Task Time/Unit (Hours)	Operators per station
1	-	A: Contact Breaker Assembly; Take Molding Half and clean burrs etc. B: Install contacts C: Install Springs	None A B A,C	0.010 0.020 0.020	1
2	1	D: Install plastic levers etc. on Molding 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	

Notes

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.

Practical Example 2

You've just been assigned the job a setting up an electric fan assembly line with the following tasks:



Task	Time (Mins)	Description	Predecessors
A	2	Assemble frame	None
B	1	Mount switch	A
C	3.25	Assemble motor housing	None
D	1.2	Mount motor housing in frame	A, C
E	0.5	Attach blade	D
F	1	Assemble and attach safety grill	E
G	1	Attach cord	B
H	1.4	Test	F, G

$$\text{Max Production} = \frac{\text{Production time per day}}{\text{Bottleneck time}} = \frac{420 \text{ mins}}{3.25 \text{ mins / unit}} = 129 \text{ units}$$

$$\textit{Required Cycle Time, } C = \frac{\text{Production time per period}}{\text{Required output per period}}$$

$$C = \frac{420 \text{ mins / day}}{100 \text{ units / day}} = 4.2 \text{ mins / unit}$$

Theoretical Min. Number of Workstations, N_t

$$N_t = \frac{\text{Sum of task times (T)}}{\text{Cycle time (C)}}$$

$$N_t = \frac{11.35 \text{ mins / unit}}{4.2 \text{ mins / unit}} = 2.702, \text{ or } 3$$

Notes

Practical Example 3

Frontec Company wants to arrange Four of its departments in a Row so that the Total Distance Traveled between Departments is minimized.

This part of the building will contain four departments arranged in a row.

Frontec wishes to minimize the total daily inter-departmental distance traveled.

The number of daily communications between each pair of department is shown below:

Pair of Departments	Number of Daily Communication
A and B	20
A and C	25
A and D	15
B and C	10
B and D	15
C and D	30

1. Assume that adjacent departments are 20 feet apart.
2. We will use a trial-and-error approach to this problem.
3. Assume that we selected the following configuration for the departments: A-B-C-D.
4. For this configuration, Total communication cost (based on distance) is as follows:

Pair of Departments	Number of Daily Communication	Distance (feet)	Total Communication Cost (Comm. x distance)
A and B	20	20	400
A and C	25	40	1,000
A and D	15	60	900
B and C	10	20	200
B and D	15	40	600
C and D	30	20	600
Total			3,700

Now we will consider a different configuration: B-A-C-D.

Pair of Departments	Number of Daily Communication	Distance (feet)	Total Communication Cost (Comm. x distance)
A and B	20	20	400
A and C	25	20	500
A and D	15	40	600
B and C	10	40	400
B and D	15	60	900
C and D	30	20	600
Total			3,400

In terms of total daily communication distance, (B-A-C-D) is the preferred alternative.

But the firm has to consider all of the 24 (4! = 4x3x2x1) possible configurations before it knows if this is the optimal configuration.

This trial-and-error approach becomes time-consuming as the number of departments increases AND It also becomes complex when the cost of communications vary between departments.

Notes

13.6.2 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.

Self Assessment

Fill in the blanks:

13. The layout-planning problem for assembly lines, is to determine the …….number of stations and assign tasks to each station, so that a desired level of output is achieved.
14. 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…….. .
15. Once the …….output is specified, we can calculate the theoretical minimum number of stations required.

13.7 Summary

- Production Management is concerned with basically the two important functions of Production which are Production Planning & Production Control.
- Production Planning is concerned with the planning of various for a given period of time so that the customer could get the right quality of products at right place, price and in time. Production.
- Production Control measures actual performance of production units and taking remedial action called for to see that production actually achieved is not less than the standard set in advance.
- Aggregate Planning may be defined as 'Intermediate Planning' which is normally done for a period of up to one year's time.
- Material Planning is a technique of determining the requirements of raw materials, components, spares etc., required for the manufacturing of the product.
- Plans have a time dimension and to the extent the time-span is restricted, the scope of functional plans also remains limited with less interaction from further functional plans.
- The short, medium and long-range plans have to dovetail into one another. Shorter range plans are for all time made within the framework of the longer range plans.
- 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.
- 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.

13.8 Keywords

Aggregate Planning: It may be defined as 'Intermediate Planning' which is normally done for a period of up to one year's time.

Notes

Master Plan: A plan that contains all the constituents of the production process that would finally lead to the resultant product.

Material Planning: It is a technique of determining the requirements of raw materials, components, spares etc., required for the manufacturing of the product.

Production Control: It measures the actual performance of production units and taking remedial action called for to see that the production actually achieved is not less than the target.

Production Planning: It is concerned with the planning of various for a given period of time so that the customer could get the right quality of products at right place, price and in time.

13.9 Review Questions

1. Production Management is concerned with basically the two important functions. Describe those two functions.
2. What is the significance of an ideal assembly line?
3. Timing decision assist the production process in accomplishment of organizational goals. Justify.
4. Production Planning and Control is to set the realization targets in terms of Standard Output, measure the actual production performance against the target set in advance and take remedial action as and when necessary. Explain.
5. Define the concept of dovetailing of plans and also signify the usage extent of this conception in production planning.
6. Describe MRP and its process. Also explain the benefits of MRP System.
7. Explain the planning that may be defined as 'Intermediate Planning' and is normally done for a period of up to one year's time.
8. Differentiate among the Production Planning Problems in Job Shop Production and Continuous Systems.
9. In what way aggregate planning contribute its significance to production management?
10. What is the importance of time horizon in production planning and controlling?

Answers: Self Assessment

1.	Production control	2.	Production Planning
3.	Mass production	4.	Different
5.	Forecast	6.	Sub contracting
7.	Graphical	8.	Material Planning
9.	Ordering	10.	Master plan
11.	Intermediate, short	12.	Demand
13.	Minimum	14.	Equal
15.	Desired		

13.10 Further Readings

Notes

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Notes

Unit 14: Operations Scheduling

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Objectives

After studying this unit, you will be able to:

- Recognize the concept of scheduling;
- Describe the diverse aspects of shop loading;
- Explain the procedure to develop gantt chart;
- Discuss various significant aspects of scheduling in services.

Introduction

Plant scheduling has indeed come a long way. It used to be some form of variation of order-point scheduling. You take an order's due date and work backwards through the bills of materials,

Notes

subtracting the times associated with producing that order, including material delivery, production, and shipping. These calculations resulted in a start date for that customer order. This process, called backward scheduling, is an approach based on averages, it doesn't consider the daily fluctuations and operating factors and conditions on the factory floor.

14.1 Scheduling

Scheduling is the problem of assigning a set of tasks to a set of resources subject to a set of constraints.

Example: scheduling constraints include deadlines (e.g., job 'i' must be completed by time 't'), resource capacities (e.g., there are only four drills), precedence constraints on the order of tasks (e.g., a piece must be sanded before it is painted), and priorities on tasks (e.g., finish job 'j' as soon as possible while meeting the other deadlines).

Example: scheduling domains include classical job-shop, manufacturing, and transportation scheduling.

The early 1960s saw the emergence of the concept of MRP. It used backward scheduling to highlight material shortages and then generate production and purchase orders to avoid those shortages. With the emergence of IT, the computerization of MRP automated the process and work associated with material requisition. These new tools rekindled the interest in plant scheduling problem and a new system, MRP II, emerged.

MRP II introduced the concept called the Master Production Schedule (MPS). MPS was a layer added on top of MRP. It also marked the end of ordering inventory based on past usage. Instead, MPS focused on sales and marketing's best guess of the future need for products. This best guess was then passed to the next planning function, namely, the next MRP run. Both MRP and MPS assume certain ideal characteristics about the imperfect world of production and the plant floor:

- Infinite resources (machine capacity and labour) are always available and do not change.
- Material resources will arrive as scheduled in the right quantities. Any variances, or missed incoming shipments, were expedited manually until the next MRP run.
- Customer orders and products have the same priority. MRP aggregates demand (customer orders) into lots and outputs.
- Lead times (production and material delivery) are fixed or proportional to lot size.
- Scheduling on a weekly basis will meet planning requirements.

Scheduling starts with the Master Production Schedule (MPS), which defines current and future (forecasted) resource requirements based on current and forecasted customer orders. Completing these orders is the goal—the MPS provides production targets toward reaching that goal. In doing so, it takes into account the technical requirements of the task and available capacity and matches it with the forecasted demand. Everything else in the planning system works from the MPS. The result is a set of purchasing and manufacturing orders with start and due dates, and a list of the minimum quantities of inventory to satisfy the MPS.

The planning system also initiates operations scheduling through capacity requirements planning.

- It starts by determining whether the enterprise has the production capacity available to build what's listed in the MPS.

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- The finished product is decomposed into required resources – labour, equipment, and even operational times – lead times are then calculated.
- The gross requirements, called rough-cut capacity, are eventually mapped against the available resources.
- If resources are in short supply, the planning system flags the affected customer and manufacturing orders so that the MPS can be recalculated.
- This information tells the enterprise when to order new materials, when to start making products from those materials, and when to distribute the finished products to end customers.

14.1.1 Operations Scheduling Models

People face scheduling problems and opportunities every day.

Example: At the railway station, someone is responsible for assigning platforms to the different trains that come in and go out. Or in a manufacturing facility, someone is in charge of assigning jobs to machines. How does one build a model that can be used under these circumstances? To build a model is quite simple.

The main components of a planning and scheduling model require that you define the variables. These could include the following:

- When are people, machines, vehicles, etc., available to do work?
- What product needs to be made or service needs to be performed?
- What is the process to make the product or perform the service?
- What resources are required to complete or perform the process (i.e., machines, people, tooling, materials, etc.)?
- How many parts do we need to make for each customer, or what services does the customer need?
- When do they need the products delivered or the services performed?

There are two basic types of scheduling exercises:

- Operations scheduling assigns jobs to machines or workers to jobs. In manufacturing, operations scheduling is crucial because many performance measures, such as, on-time delivery, levels, the manufacturing cycle time, cost, and quality, relate directly to the scheduling of each production lot.
- Workforce scheduling determines when employees work. In service organizations, workforce scheduling is equally crucial because measures of performance such as customer waiting time, waiting-line length, utilization, cost, and quality are related to the availability of the servers.

Perhaps the most fundamental questions in scheduling are:

- What is the capacity?
- How do you balance load and capacity?

Capacity has two basic types of constraints—a hard ceiling and a soft ceiling.

Notes

14.1.2 Hard Ceilings

Hard ceilings are where the capacity is extremely difficult to flex.

Example: A major piece of capital equipment which runs at a fixed rate such as a heat treatment process, where process times are fixed, or production line where the track rate is fixed. In this case, all you can do is maximize utilization, avoid breakdowns and quality problems, and ensure that it is always working to customer needs. Or a hard ceiling may be due to a job requiring a scarce skill that is difficult to train, such as is often encountered in tool making or maintenance.

There is a limit to how much overtime can be worked to meet demand, and the training program to reach basic skills is protracted. In both cases, it is difficult to increase output above a given level and sub-contracting is not practicable for quality reasons, or lack of availability of suitable sources.

14.1.3 Soft Ceilings

Soft ceilings can be flexed by scheduling manpower, buying additional inexpensive plant machinery, recruiting unskilled or semiskilled staff, or sub-contracting, or overtime. The essential differences between the two types of capacity constraint are cost and lead time, which need to be built into the calculations.

In addition, we also need to define the rules that are to be used to assign work to the resources (schedule) in the model. These rules could be very simple such as:

- Select the task that is due the soonest (earliest due date).
- Select the task that requires the least amount of time to complete (shortest processing time).
- Select the task that requires the least amount of set up time or clean up time or travel time.

In the real world, it is usually the case that the rules are not very simple. These could also be very complex such as:

- Select the task that is due the soonest unless there are any tasks to be completed for Customer A, in which case all tasks for Customer A should be completed first.
- Select the task that uses the same tooling, has the same colour, and the same due date as the last task completed by a particular resource.
- Select the task that allows the resource used to be completed or prepared for another task by a certain time.
- Select the resource that best meets all skill requirements to complete the specific task (i.e., allocate repairmen to service calls where each service call will require a certain skill set and the repairman will have that skill set).

Complex rules are very often just a combination of – or exceptions to – the simple rules. These combinations and exceptions make planning and scheduling a difficult task. Scheduling models can be broadly classified into two categories—continuous or intermittent conversion processes. A continuous or assembly type system is one where a large number or indefinite numbers of homogenous units are produced. On the other hand, an intermittent system produces a variety of products either one at a time or in batches. Some processes have the characteristics of both these types of systems, they are neither strictly continuous nor intermittent.

Notes

Notes The operations schedule is that part of the planning system designed to implement the MPS by focusing on how best to use existing capacity, taking into account technical production constraints. The output plan of either of these systems needs to be translated into operations, timing and schedule on the shop floor. This involves loading, sequencing, and detailed scheduling expediting and input/output control. In intermittent or job shop operations, sequencing is critical to the efficiency and effectiveness of the system.

14.1.4 Sequencing

When numbers of jobs are waiting in queue before an operational facility (such as, a milling machine or assembly-line), there is a need to decide the sequence of processing the waiting jobs. Sequencing is basically an order in which the jobs, waiting before an operational facility, are processed. It specifies the order required for the adoption of priority sequencing. In addition, it also requires an in-depth knowledge of processing time, etc.

14.1.5 Detailed Scheduling

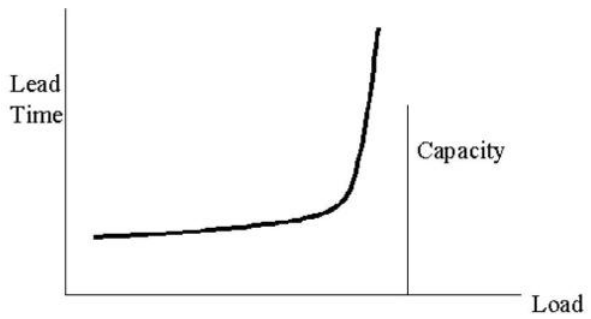
Detailed times and dates are specified once the priority rule of job and/or operations sequencing is known. Calendar times are specified to sequence the job orders, employees, inputs as well as outputs. This order determines which job is done first, which is the next one's and so on. In detailed scheduling, estimates are prepared regarding set up and processing time at which a job is due to start and finish.

14.1.6 Expediting

A job's progress needs monitoring. The job has to keep moving through the facility on time to avoid a deviation from the schedule. In case of deviation from the schedule, the causes of deviation are immediately attended to. Manufacturing or service operations inventory disruption,

Example: Due to machine breakdown, non-availability of a tool, unavailable materials, etc., and, sometimes last minute priority changes, all require last minute deviations from plans and schedules. In order to minimize disruptions in schedules, continuous follow up or expediting is needed.

Figure 14.1: 'Thrashing' – Impact on Lead Time and Capacity



When lead times are not managed, overloads will occur. What happens is illustrated in the following diagram. This shows that as capacity is reached, the manufacturing system starts to

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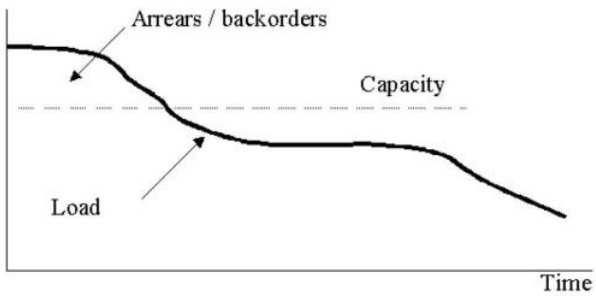
'thrash'. 'Thrashing' is the problem of the system keeping itself busy re-planning rather than producing, which effectively reduces capacity. This results in problems similar to mainframe computers where this problem was first documented, lots of expediting, customer panics and increased changeovers. The result is an effective reduction in batch sizes, as you spend more time changing over than producing due to batch splitting.

Figure 14.1 shows a gradual increase in lead time as load increases up to the point where 'thrashing' occurs and where lead times go through the roof.

14.1.7 Input-output Control

Output plans and schedules call for certain levels of capacity at a work center and those jobs are completed at a specific time on every facility. In a real world situation, the utilization of the capacity of a facility may be different from the plans – under-utilization of capacity means wasted resources and over-utilization may cause disruption, failure, and delays. These differences are monitored through input-output reports.

Figure 14.2: Thrashing due to 'Failure to Adjust'



These reports form the basis for adjustments to the schedule. If arrears are not rescheduled in conjunction with the customer, they create a short-term overload of equal due dates, which induce 'thrashing'. The customers are still expecting their order, unless the adjustments are communicated to customers.

Figure 14.2 shows the impact of arrears on scheduling causing 'thrashing'. The solution is to reschedule arrears, in conjunction with customers and manage lead times.

14.1.8 Non-cyclic Personnel Schedules

Demand variations are often caused by trend and seasonal factors, holidays, etc. Depending on the nature of the particular operations, suppose that we are faced with labor requirements that vary from hour to hour, day to day, week to week, and so on. Staffing this operation would require continuous adjustment to the changing requirements. These types of personnel scheduling use the 'first-hour' principle. The principle can be stated as follows:

> *"Assign the work in the first period to a number of workers equal to the number required for that period. For each subsequent period, assign the exact number of additional workers needed to meet requirements. When workers come to the end of their shifts, do not replace them if they are not needed".*

This procedure is best exampled with the aid of an example. The sequence of worker requirements for the first 12 hours of a continuous operation (one assigned, workers continue working for an 8-hour shift) are given in Rows '1' and '2' of Table 14.1.

Notes

Table 14.1: Requirement and Assignment of Workers

Period	1	2	3	4	5	6	7	8	9	10	11	12
Requirements, R_i	6	6	8	8	10	10	15	14	12	12	14	14
Assigned, X_i	6	-	2	-	2	-	5	-	3	-	4	-
On duty , W_i	6	6	8	8	10	10	15	15	12	12	14	14

Using the 'first-hour' principle, Xi = 6 workers are assigned in period 1 to work 8 hours. No additional workers are needed in period 2 because the requirement of 6 workers does not change.

However, 2 additional workers must be assigned in period 3 to meet the total requirements of 8. In period 8, a total of WI = 15 workers are on duty. The 6 workers who were assigned in period 1 complete their shifts at the end of period 8, leaving a residential of 9 workers who continue into period 9.

But 12 workers are required in period 9, so 3 additional workers must be assigned to start their shifts. In period 11, the requirement for workers goes up to 14, but 2 workers have completed their 8-hour shift, so 4 new workers are assigned.

The assignment procedure continues in the same way, in an endless chain, as new requirements become known.

14.1.9 Scheduling Rules for the Workforce-Cyclic Personnel Schedules

One way to manage capacity in a scheduling system, with a stable situation in which the requirements pattern repeats itself, is to specify labour-assignment rules. The following are some examples of labour-assignment rules.

- Assign personnel to the workstation having the job that has been in the system longest.
- Assign personnel to the workstation having the most jobs waiting for processing.
- Assign personnel to the workstation having the largest standard work content.
- Assign personnel to the workstation having the job that has the earliest due date.

Determining the workdays for each employee does not make the staffing plan operational. Daily workforce requirements, stated in aggregate terms in the staffing plan, must also be satisfied. In addition, customers demand quick response and reality is that total demand cannot be forecast with reasonable accuracy. The capacity needs adjustment to meet the expected loads. Therefore, the workforce capacity available each day must meet the daily workforce requirements. If it does not and no such schedule can be found, management might have to change the staffing plan and authorize more employees, overtime hours, or larger backlogs.

Optimal solutions to cyclic staffing problems can be developed by applying the first-hour principle successively to the requirements schedule until the assignment pattern repeats. Suppose that we are interested in developing an employee schedule for a company that operates seven days a week and provides each employee one day off.

The objective is to identify the days off for each employee that will minimize the amount of total slack capacity. The work schedule for each employee, then, is the six days that remain after one day off has been determined. The procedure involves the following steps.

Notes

Step 1

- From the schedule of net recruitments for the week, find all the days that exclude the maximum daily requirements.
- Select the day that has the lowest total requirements.
- Select the day with the lowest total requirements.
- Suppose that the numbers of employees required are.

Monday:	8	Tuesday:	9	Wednesday:	12	Thursday:	12
Friday:	10	Saturday:	8	Sunday:	4		

The maximum capacity requirement is 12 employees, on Wednesday. The lowest total requirement is on Sunday with 4 workers.

Step 2

- If a tie occurs, choose any one of the tied days. The tie could be broken by asking the employee who is being scheduled to make the choice.

Step 3

- Assign the employee the selected day off.
- Subtract the requirements satisfied by the employee from the net requirements for each day the employee is to work.

In this case, the employee is assigned Sunday off. After requirements are subtracted, Monday's recruitments are 7, Tuesday's is 8, Wednesday's is 11, Thursday's is 11, Friday's is 9, and Saturday's is 7. Sunday's requirements do not change because no employee is yet scheduled to work on those days.

Step 4

- Repeat steps 1-3 until all requirements have been satisfied or a certain number of employees have been scheduled.

This method reduces the amount of slack capacity assigned to days having low requirements and forces the days having high recruitments to be scheduled first.

Self Assessment

Fill in the blanks:

1. …… is basically an order in which the jobs, waiting before an operational facility, are processed.
2. Scheduling starts with the ……, which defines current and future resource requirements based on current and forecasted customer orders.
3. …… can be flexed by scheduling manpower, buying additional inexpensive plant machinery, recruiting unskilled or semiskilled staff, or sub-contracting, or overtime.

Notes

14.2 Loading

In continuous processes, different sub-assemblies have to be loaded to bring out the final product. In intermittent processes, each customer job order has its unique product specifications. This requires the routing to be unique, and certain operations need to be performed on various work centers or facilities.

During each planning period, jobs orders are assigned on facilities, thereby establishing how much of a load each work center must carry. This ultimately determines the workload or jobs to be performed in a planned period. This assignment is known as machine loading.

Notes There is a concept of finite and infinite loading.

- When the loading is determined by the maximum capacities of the machines, it is called finite loading.
- In infinite loading, the maximum capacity of the machines is not the basis for assigning tasks to it. This option is applied when excess load can be handled by overtime, sub-contracting or by shifting to other work centers or time slots.

14.2.1 Shop Loading

A shop load is approved from the most heavily loaded work center to the slightest loaded.

Load by Days

The Load by Days for a Work Center identifies probable bottlenecks over the next several weeks because of overloading. You can view the detail for any precise day to see what jobs will be scheduled at the Work Center.

Perform modeling and "what if" analyses to see the credible effect of increasing Work Center capacity and/or modifying job schedules.

How it Works?

The Loading module organizes each and every one open operation for active jobs by work centers. The module automatically maintains real-time information that let you to decide potential shop bottlenecks, prioritize operations at work centers, expedite jobs and allocate resources to optimize shop throughput. A Dispatch List Report be able to viewed, printed and sent to the shop floor for shop personnel to decide the most efficient sequencing of jobs at the same time as meeting customer delivery requirements.

After a job is entered and has been automatically scheduled, the Loading module presents shop floor activity in real-time as it takes place on several screens:

The work center Load by Days graph provides a snapshot of a particular work center's scheduled load on a day-to-day basis and identifies overloaded work centers and potential bottlenecks.

Contributing Jobs

The Work Center Contributing Jobs offer a list of all jobs scheduled at a particular work center for a selected day. You can drill down to the details of every scheduled operation to help determine how the work center load can be adjusted to meet up your shop demands.

Notes

Load/Schedule

The work center Load/Schedule provides a tool for analyzing the load at an exact work center and suggesting the order in which work should be performed previous to printing or viewing a Dispatch List Report.

Job Queue Status

The Job Queue Status provides a real-time status of a job's operations. You can check the job's progress on the shop floor and compare estimated against actual hours for each operation. Also, real-time loading information is shown for each Work Center on which the job is scheduled.

Finite Modeling

The work center Finite Modeling displays the daily scheduled load for a work center plus provides "what if" analysis capability to see the effect on the daily load of moving a job's operations.

14.2.2 Index Method

A heuristic technique of loading, which would yield better results than the simple and intuitive method is index method. Supposing time is the criterion, 'indices' are calculated for the diverse process times (if done in work centres) with the lowest process time having the base index of 1.0. The lowest index jobs are afterward assigned to the work centres, keeping in view the limitations of the capacities of the centres. The next lowest index jobs are then assigned to the work centres (devoid of exceeding the constraints on capacities), and this process is constant till all the jobs are assigned. This is a heuristic method and the solution obtained may not be optimal; though it could be near optimal.

Task Is job-shop scheduling a planning activity or a control activity? Would you call these four activities loading, sequencing, detailed scheduling, and input-output control as shop floor control? Explain.

Self Assessment

Fill in the blanks:

4. In …… processes, different sub-assemblies have to be loaded to bring out the final product.
5. In …… processes, each customer job order has its unique product specifications.
6. The Job Queue Status provides a …… status of a job's operations.

14.3 Gantt Charts

Gantt charts were developed in the 1910's by Henry Gantt (1861-1919), a mechanical engineer, management consultant, and industrial advisor. The chart takes two basic forms:

1. The job or activity progress chart and
2. The machine chart.

Both types of Gantt charts present the ideal and the actual use of resources over time. The progress chart graphically displays the current status of each job relative to its scheduled

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completion date. A visual tool, the charts allow us to obtain a bird's eye view of the process in its totality. From beginning to end the charts force us to:

1. Make a realistic assessment of the end-time of the process.
2. Sequence our tasks (or phases, or activities)—one after the other, as well as in parallel.
3. Think in terms of task dependencies—which task is dependent on what.
4. Concentrate on the necessary resources, both when and where, throughout the run of the process.

There are many ways to create a Gantt chart.

Example: Microsoft Project, a task-planning program, makes it easy to track and chart project timeliness with a built-in Gantt chart view. Another option is to use Excel. Excel does not contain a built-in Gantt chart format, however, you can create a Gantt chart in Excel by customizing the stacked bar chart type.

The procedure for making a Gantt chart using MS Excel is given below.

Step 1: The first step is to enter the sample data

Open a new worksheet in Excel and enter the following values in cells A1 through D6:

Table 14.2: Data for the Gantt Chart

	A	B	C	D
1		Start Date	Completed	Remaining
2	Task 1	08/01/2000	205	10
3	Task 2	10/15/2000	200	120
4	Task 3	12/15/2000	140	200
5	Task 4	02/06/01	44	345
6	Task 5	05/06/01	0	380

The values in columns C and D (Completed and Remaining) represent numbers of days. You can select cell B2 and format with the date format you want to use for the chart by clicking Cells on the Format menu, and then clicking the Number tab. Click Date in the Category list, and select the format you want to use in the Type list.

Step 2: Create a stacked bar chart

1. Select cells A1:D6 and click Chart Wizard.
2. In step 1, click Bar under Chart Type, and then click the Stacked Bar sub-type (you can see the name of each chart sub-type at the bottom of the dialog box).
3. Click Next, Next, and then Finish.

Step 3: Make the chart look like a Gantt chart

1. Double-click the first series in the chart. This is the series for start date. If default colours are set in Excel 2002, this series is blue.

Notes

2. On the Patterns tab of the Format Data Series dialog box, click None for Border and None for Area, and then click OK.
3. Double-click the category (x) axis, which in a bar chart is the vertical axis. (In a bar chart, the traditional x and y-axes are reversed.) Click the Scale tab, and select the Categories in reverse order check box.
4. Click the Font tab, click 8 under Size, and then click OK.
5. Double-click the value (y) axis, which in a bar chart is the horizontal axis. After completing the last step, this axis should be located at the top of the chart plot area. Click the Scale tab and type the following values3 in the appropriate boxes: Minimum: 36739; Maximum: 37441; Major unit: 61; Minor unit: 1.
6. Also on the Scale tab, select the Category (X) axis crosses at maximum value check box.
7. Click the Alignment tab, and under Orientation, type 45 in the Degrees box.
8. Click the Font tab, and under Font style, click Bold. Under Size, click 8, and then click OK.
9. Right-click the legend, and click Format Legend on the shortcut menu.
10. Click the Placement tab, and click Bottom.
11. Within the legend, click Start Date so that it is selected, and then press DELETE.

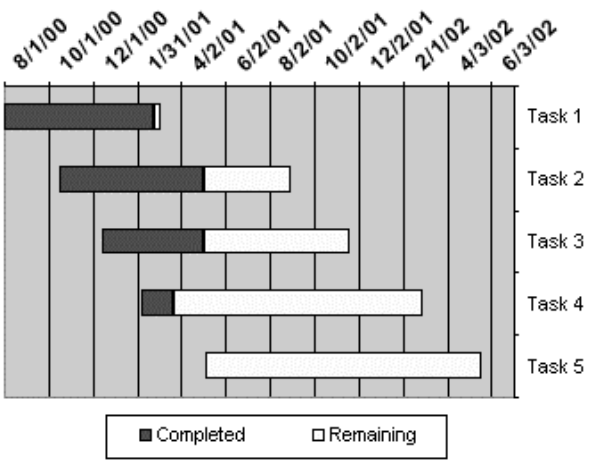
After completing these steps, you should have a chart that looks similar to the example in Figure below. You may need to resize the chart using the mouse to see all the labels present in the chart. Additional formatting can be added as needed.

What has been described is for a simple project. Ideally, tasks in simple projects would not go beyond a single page, which makes them manageable. Often, and especially in complex manufacturing schedules, each task may be broken into smaller and more easily manageable subtasks. These subtasks may be moved to subordinate charts, with their own timelines.

Did u know? **What is Work Breakdown Structure?**

In management terminology, the process – of breaking up of these tasks into independent unit-tasks that can be completed on their own – has been given an exotic name of WBS, or 'Work Breakdown Structure'.

Figure 14.3: A Gantt Chart Made using MS Excel



Notes

This process enables the manager's mind to grasp the process in its entirety as well as to think in terms of allocating resources, assign responsibilities, and measure and control the schedule, for every task and sub-task.

Once the Gantt charts are drawn up, we start comparing our actual, ground-level performance against what was planned. This comparison is possible by checking the progress reports against the Gantt charts.

Self Assessment

Fill in the blanks:

7. Gantt charts were developed in the 1910's by…… .
8. The Gantt chart takes two basic forms which are the job or activity progress chart and the …… chart.
9 After the Gantt charts are drawn up, we start comparing our actual, ground-level performance against what was …… .

Caselet

Bharat Petroleum Corporation Limited

The Indian oil industry was brought under government control after the oil crisis in the 1970's. On January 24, 1976, the Burmah Shell Group of Companies was taken over by the Government of India to form Bharat Refineries Limited. On August 1, 1977, it was renamed Bharat Petroleum Corporation Limited (BPCL).

After liberalization, under the economic reform process, the private sector entered several areas within the industry and emergence of additional capacities in the region in refining and marketing. Added competition, due to the opening up of the Indian economy, brought in other challenges. Provoked by the phased dismantling of the Administered Pricing Mechanism (APM), and anticipating radical changes in the business environment after deregulation, BPCL undertook a massive exercise for preparing itself to face these challenges.

BPCL's change initiative started towards the end of 1996 with the help of Arthur D Little, Inc. (ADL). ADL's methodology involved a cross-section of the organization in co-creating a vision for the company, determining its current reality, conceptualizing the gaps between vision and current reality, and finally evolving a change plan to bridge these gaps.

BPCL has always enjoyed the image of a progressive organization. It is, in fact, the only Indian company to have won the CIO Global 100 award for its use of technology and forward looking human resource (HR) policies. Also, it was the only public sector organization to figure in the top ten best employers in India in the Business Today survey in 2001.

In tangible terms, the change plan resulted in restructuring and radical delayering of the organization. The function-based structure was carefully dismantled and replaced with a process-based one, to make the company more responsive to its customer needs. The entire change plan necessitated effective integration and was premised on a massive increase in the information intensity of the organization. It involved change process that

Contd...

Notes

would transform BPCL into a learning organization (Senge, 1990) and IT would contribute significantly in this. Thus began the project for evolving an information system for the organization.

A small team of nine people set out to map the existing business systems (legacy systems) vis-à-vis the future needs characterized by customer focus, resource-optimization, integration, and flexibility. The challenge was to ensure that all the integrated elements (of the complex multi-modular integrated solutions that impact the entire workflow of the organization) work seamlessly across the length and breadth of the country, including the remote locations. The team concluded that it was imperative to replace the existing batch-process-oriented legacy systems with a state-of-the-art ERP system.

A detailed technical selection process was undertaken to find the 'best fit' ERP package for current and future needs of BPCL. SAP R/3 software was selected for implementation. The top management decided to name the project for implementation of SAP R/3 as project for implementation of SAP R/3 as project ENTRAINS, a short form for Enterprise Transformation. The name signified the top management's vision of a totally transformed organization—a new BPCL. "The unique thing about BPCL's ERP implementation is that right from its conception – it has been a business initiative. We just performed the necessary catalytic role" –paradoxically, this expression of pride came from the Head of IT in BPCL.

The SAP modules implemented during the pilot implementation were Financial Accounting/Asset Management, Materials Management at Refinery and Marketing Locations, Sales and Distribution, Quality Management, Plant Maintenance and Service at Refinery and Marketing Locations, Production Planning at Two Lube Plants, and the Indian version for Excise, MODVAT, TDS, Sales Tax, Octroi, etc.

However, implementing the program was not easy. For example, at Wadilub, the staff thought many simple tasks had now become tedious involving many steps and demanding longer working hours than before. The system would not allow them to take short cuts that they were used to. For instance, container suppliers used to directly despatch containers to the third party blenders without making Goods Receipt (GR) and Goods Issue (GI). The system would not physically receive if it did not have any issues for such materials. It would require the necessary documentation at both ends of a transaction to register. In addition, many configuration problems were also encountered, causing agitation among the staff.

Notwithstanding these difficulties, Mr. Vairamohan, the Plant Manager, recounted the benefits from the pilot implementation saying, "SAP system imposed strict discipline among the staff to follow a certain sequence of operation. As a result, there is no suspense issue at Wadilub today. We are able to get many logistics information such as material inventory, product despatches, and pending indents".

Bharat Petroleum found that by having information available, its capabilities along the entire value chain were enhanced. It is reaping the benefits of the integrated system in many areas of its operations. The early gains of implementation were in the areas of tracking customer-receivables, monitoring credit-management, inventory management, besides easing the operations in a large number of areas. It also enabled the management to take better strategic and business decisions, thus ensuring value-added services, better customer satisfaction and enhanced shareholder value.

Source: Upendra Kachru, Production and Operations Management – Text and Cases, First Edition, Excel Books, New Delhi 2007.

Notes

14.4 Job Shop Scheduling

The Gantt chart gives a relationship among different activities in a production process in terms of their completion time. However, a Gantt chart does not provide an optimal sequence of jobs. Many jobs in industry and elsewhere require completing a collection of tasks while satisfying temporal and resource constraints. Temporal constraints say that some tasks have to be finished before others can be started; resource constraints say that two tasks requiring the same resource cannot be done simultaneously (e.g., the same machine cannot do two tasks at once). The objective is to create a schedule specifying when each task is to begin and what resources it will use that satisfy all the constraints while taking as little overall time as possible. This is the job-shop scheduling problem.

In its general form, there is probably no efficient procedure for exactly finding shortest schedules for such problems. However, by giving the scheduling tools some flexibility and guidance, it is possible to produce a schedule that best uses the existing capacity. We will discuss some algorithms in the following paragraphs. It should be kept in mind that these algorithms that are applicable to job shops are also applicable to all flow shops that have similar characteristics.

To identify the performance measures, we will introduce some new measures, makespan and utilization.

Did u know? **What is Makespan?**

The total amount of time required to complete a group of jobs is called makespan. This is the sum total of the flow time for individual jobs.

Utilization: The per cent of work time productively spent by a machine or worker is called utilization. Utilization for more than one machine or worker can be calculated by adding the productive work times of all machines or workers and dividing by the total work time they are available.

Makespan = Time of completion of last job – Starting time of first job

Utilization = Productive work time/ Total work time available

These performance measures are often interrelated.

Example: In a job shop, minimizing the mean job flow time tends to reduce work-in-process inventory and increase utilization. In a flow shop, minimizing the makespan for a group of jobs tends to increase facility utilization. An understanding of the interactions of job flow time, makespan, past due, WIP inventory, total inventory, and utilization can make scheduling easier.

Scheduling of 'n' Jobs on 1 Machine (n/1 Scheduling)

This type of scheduling problem is called the (N/1) scheduling problem. When many jobs are waiting before an operational facility, we must have some heuristic or rule to decide the priority while sequencing. Generally, this type of scheduling is done using simple scheduling procedures. For scheduling simple jobs, some of the basic procedures that are used are First Come First Served (FCFS), Shortest Production Time (SPT), Due Date (D Date), Last Come First Served (LCFS), Random, and Slack Time Remaining (STR) rules.

Notes

First Come First Served and Last Come Last Served

These terms reflect exactly what they say. In the former, jobs are scheduled on the basis of their arrival. In the latter, the last arrival is scheduled first and the first arrival scheduled last.

Shortest Processing Time Procedure

A schedule obtained by sequencing jobs in increasing order of processing times is called a shortest processing time (SPT) rule.

This schedule minimizes mean flow time, F. In addition, the SPT rules also minimize mean lateness and mean waiting time. The mean flow time is computed by simply adding the flow time for each job and dividing by the number of jobs.

Due Date Procedure: In the due date procedure, jobs are sequenced in the order of decreasing due dates. The job with the earliest due date will be sequenced first. The due date procedure minimizes the maximum tardiness.

Caution: Random: Jobs are chosen randomly. There is no apparent logical method of scheduling jobs.

Slack Time Remaining: The STR is the difference between the time remaining before the due date and the remaining processing time.

The 'SPT sequencing rule' shows better performance, compared to the other scheduling rules, when there are many jobs for a single machine. SPT minimizes the total flow time, average flow time, and average tardiness of jobs, etc., in most cases. An example will make it easier to visualize the impact of the different rules on scheduling. Before going to the example, let us define some of the terms that we are going to use.

Each job in a one machine-scheduling model (n/1 scheduling) is described by two parameters, where 'i' is the number of the sequence of the job.

p_i = Processing time for the 'i'th job

d_i = Due date of the 'i' th job

The definition of p_i includes set up time for job 'i'. If job 'i' is defined as a lot of several identical pieces, then pi will denote the time required to process the complete batch. The due date is the time by which a job must be completed, otherwise, the job will be deemed late.

F_i is the 'flow'; it is the amount of time the 'ith' job spends in the system. The 'makespan' is the cumulative time it takes the shop to complete all the jobs. Lateness, L_i is the amount of time by which the completion time of job 'i' exceeds its due date. Lateness is designated as 'L_i'. As lateness can be either positive or negative, a positive lateness, i.e., when the due date is not met is called tardiness, T_i.

Thus, tardiness is a measure of the deviation of the completion time from the due date. Since there is often a penalty associated with not meeting due dates, the tardiness measure is important.

Flow Time $= F_i = C_i - r_i = F_{(i-1)} + pi$

Makespan = Total flow time = $\sum_{i=0}^{n} F_i$

Mean flow time = Total flow time/Number of jobs = $\sum_{i=0}^{n} F_i/n$

Lateness of Job $= L_i = F_i - d_i$.

Tardiness of Job $= T_i = F_i - d_i$ if $F_i > dn$ otherwise $T_i = 0$

Notes

Total Tardiness $= \sum_{i=0}^{n} L_i$

Average Tardiness $= \sum_{i=0}^{n} L_i/n$

In our example, we assume there are five products waiting for getting processed on a machine. Their sequence of arrival, processing time and due-date are given in the table on the next page. We will try to schedule the jobs for the different products, P1, P2, P3, P4, and P5 using the different scheduling rules, i.e., FCFS, SPT, D Date, LCFS, Random, and STR rules. We will then compare the results.

Table 14.3: n/1 Scheduling for Job Shop

Job (In Sequence of Arrival)	Processing Time = p_i (Days)	Due Date = d_i (i.e., Days From Now)
P1	3	6
P2	3	8
P3	5	8
P4	7	10
P5	4	4

The calculations are shown in Tables below. To make the calculations easier to understand, a column of 'sequence' that reflects the results of the selection criteria, has been inserted before the calculations of each of the techniques. We can follow the calculations shown in the tables more clearly, by calculating the flow and tardiness in the case of the First Come First Served rule. The calculations are shown below:

Makespan = $\sum_{i=0}^{n} F_i$ = 3 + 6 + 11 + 18 + 22 = 60 days

Mean flow time = 60/5 = 12 days

Total lateness of job = 0 + 0 + 3 + 8 + 18 = 29 days

Average lateness of job = 29/5 = 5.8 days

Similarly, calculations can be made for the other procedures. The calculated values are given in the two tables that follow.

Table 14.4: Scheduling Parameters for our Example (1)

FCFS			SPT			D Date		
Sequ-ence	Flow Time	Tardi-ness	Sequ-ence	Flow Time	Tardi-ness	Sequ-ence	Flow Time	Tardi-ness
P1	3	0	P1	3	0	P5	4	0
P2	6	0	P2	6	0	P1	7	1
P3	11	3	P5	10	0	P2	10	2
P4	18	8	P3	15	7	P3	15	7
P5	22	18	P4	22	12	P4	22	12
Totals	60	29		56	19		58	22

Notes

Table 14.5: Scheduling Parameters for our Example (2)

LCFS			Random			STR		
Sequence	Flow Time	Tardiness	Sequence	Flow Time	Tardiness	Sequence	Flow Time	Tardiness
P5	4	0	P3	5	0	P5	4	0
P4	11	1	P1	8	2	P1	7	0
P3	16	3	P4	15	5	P4	14	6
P2	19	11	P5	19	11	P3	19	11
P1	22	16	P2	22	16	P2	22	16
	72	31		69	34		66	33

Table below is a comparison of the different scheduling procedures which we have considered above. It will be seen that no other sequence can produce a better mean flow time than the sequence obtained by the SPT rule. Also, the 'average tardiness' is the lowest using the STP procedure. The optimality of the SPT rule can be mathematically proved. By finishing the shorter jobs first, both the turnaround time and the work-in-process inventory are reduced. The SPT procedure is simple to implement and provides good results even in the more complex scheduling situations.

Table 14.6: Comparison of Scheduling Procedures

Scheduling Rule	Makespan (days)	Mean Flow Time (days)	Average Tardiness
FCFS	60	12.0	29/5
STP	56	11.2	19/5
D – Date	58	11.6	22/5
LCFS	72	14.4	31/5
Random	69	13.8	34/5
STR	66	13.2	33/5

However, STP could increase total inventory value because it tends to push all work to the finished state. It also tends to produce a large variance in past due hours because the larger jobs might have to wait a long time for processing. As it provides no opportunity to adjust schedules when due dates change, the advantage of this procedure over others diminishes as the load on the shop increases.

Self Assessment

Fill in the blanks:

10. …… constraints say that some tasks have to be finished before others can be started.
11. …… constraints say that two tasks requiring the same resource cannot be done simultaneously.
12. A schedule obtained by sequencing jobs in increasing order of processing times is called a …… rule.

Notes

14.5 Scheduling in Services

There are some basic distinctions between manufacturing and services. These differences effect scheduling. Service operations cannot create inventories to buffer demand uncertainties. Also service operations demand is often less predictable. If my computer starts misbehaving, a service engineer is required. Customers may decide on the spur of the moment that they need a dosa or a haircut. Thus capacity, often in the form of manpower and skills, is crucial for service providers. In this section, we discuss various ways in which scheduling systems can facilitate the capacity management of service providers.

Caution It must be remembered that demand for service is often initiated by unplanned events.

Scheduling Customer Demand

Where demand is known in advance or can be forecast, a way to manage capacity is to schedule customers for arrival times and definite periods of service time. This is a level strategy option that was discussed. Capacity remains fixed and demand is leveled to provide timely service and utilize capacity. Three methods are commonly used: backlogs, reservations, and appointments.

Backlogs: Very often organizations allow backlogs to develop so that they can plan their capacities better. Various priority rules can be used to determine which order to process next. The usual rule is first come, first served. But in a service industry custom and previous experience often changes the order of priority.

For example, your tailor shop will not tell you exactly when service will commence. You give your measurements (service request) to a tailor (order taker), who adds it to the waiting line of orders already in the system and he gives you a date for trying out the outfit.

Reservations: In many industries like in the hospitality and travel trades, reservations have become a norm. Reservations systems, although quite similar to appointment systems, are used when the customer actually occupies or uses facilities associated with the service.

The major advantage of reservation systems is the lead time they give service managers to plan the efficient use of facilities. Reservations often are complicated by the problem of no-shows. Yield management techniques have been developed to enhance demand for services as well as minimize the negative impacts of reservation systems.

Appointments: An appointment system assigns specific times for service to customers. The advantages of this method are:

- Timely customer service and
- High utilization of servers.

Hospitals are examples of service providers that use appointment systems. Surgeons can use the system to schedule part of their day to see patients and part of the day for their surgery. The quality of service is determined by the care taken to control delays in appointments so that individual customer needs are satisfied.

Fortunately, many service products have soft ceilings. Soft ceilings can be flexed by buying additional inexpensive plant, recruiting unskilled or semiskilled staff, or sub-contracting, or of course short term overtime. Such service products can also use a 'chase strategy'. However, jobs requiring a scarce skill that is difficult to train such as toolmakers, or maintenance operatives, there is a limit to how much overtime can be worked to meet demand and the training program to reach basic skills is protracted.

Notes

Self Assessment

Fill in the blanks:

13. The major advantage of reservation systems is the ……, they give service managers to plan the efficient use of facilities.
14. …… techniques have been developed to enhance demand for services as well as minimize the negative impacts of reservation systems.
15. …… can be flexed by buying additional inexpensive plant, recruiting unskilled or semiskilled staff, or sub-contracting, or of course short term overtime.

14.6 Summary

- Scheduling is the problem of assigning a set of tasks to a set of resources subject to a set of constraints.
- Capacity has two basic types of constraints—a hard ceiling and a soft ceiling.
- Sequencing is basically an order in which the jobs, waiting before an operational facility, are processed.
- A shop load is approved from the most heavily loaded work center to the slightest loaded.
- An index method is a heuristic technique of loading, which would yield better results than the simple and intuitive method.
- Gantt chart is a visual tool that takes two basic forms—the job or activity progress chart and the machine chart. Both types of Gantt charts present the ideal and the actual use of resources over time.
- The Gantt chart takes two basic forms which are The job or activity progress chart and The machine chart.
- A schedule obtained by sequencing jobs in increasing order of processing times is called a shortest processing time (SPT) rule.
- Where demand is known in advance or can be forecast, a way to manage capacity is to schedule customers for arrival times and definite periods of service time.

14.7 Keywords

Gantt Chart: It is a visual tool that takes two basic forms—the job or activity progress chart and the machine chart. Both types of Gantt charts present the ideal and the actual use of resources over time.

Hard Ceilings: It is for capacity are limits that make the capacity extremely difficult to flex.

Scheduling: It is the problem of assigning a set of tasks to a set of resources subject to a set of constraints.

Sequencing: It is basically an order in which the jobs, waiting before an operational facility, are processed.

Soft Ceilings: It is for capacity are limits that make the capacity reasonably easy to flex.

14.8 Review Questions

1. The main components of a planning and scheduling model require that you define the variables. What would it include?

Notes

2. The Gantt chart takes two basic forms. What are those forms?
3. Both MRP and MPS assume certain ideal characteristics about the imperfect world of production and the plant floor. What are they?
4. Capacity has two basic types of constraints. Explain those constraints.
5. What is the procedure for making a Gantt chart using MS Excel?
6. Explain a heuristic technique of loading, which would yield better results than the simple and intuitive method.
7. Describe the conception of job shop scheduling.
8. To identify the performance some new measures are being introduced. What are those measures?
9. Scheduling for manufacturing industries and service industries are same. Do you agree? Justify your answer with examples.
10. What are the three methods that are commonly used for scheduling customer demand?

Answers: Self Assessment

1. Sequencing
2. Master Production Schedule
3. Soft ceilings
4. continuous
5. intermittent
6. real-time
7. Henry Gantt
8. machine
9. planned
10. Temporal
11. Resource
12. shortest processing time
13. lead time
14. Yield management
15. Soft ceilings

14.9 Further Readings

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