QUALITY MANAGEMENT

Total Quality Management (TQM) is a strategic, integrated management system for achieving customer satisfaction. It involves all managers and employees and uses quantitative methods to continuously improve an organization's processes. It is not an efficiency (cost-cutting) program, a morale-boosting scheme, or a project that can be delegated to operational managers or staff specialists.

Elements of TQM

Three essential requirements or principles of TQM are: (1) the pursuit of complete customer satisfaction by (2) continuously improving products and services, through (3) the full and active involvement of the entire workforce.

What is Different about TQM?

Components of TQM

- Process management
- Quality teams
- Quality councils
- Ongoing training

Common Areas of Agreement on Quality

- Producing a quality product costs less because there is less waste.
- Preventing quality problems is better than detecting and correcting them.
- Statistical data should be used to measure quality.
- Managers need to take a leadership role in improving quality.
- Managers and employees need training in quality improvement.
- Companies need to develop a Quality Management System.

The following areas need to be improved:

- Many managers encourage employee involvement and empowerment, but few organizations adopt the specific practices that bring them about, such as reliance on teams of employees to identify and resolve specific operating problems. Where teams are used, few have been delegated sufficient authority to make changes or have been trained to use the full array of TQM tools.

Common Areas of Agreement on Quality (continued)

- Although many organizations recognize the importance of measurement and analysis to decision-making, many measure the wrong things. Also, few organizations focus on internal processes across functions in order to assure that quality is built into the production and service system on a continuing basis.
- Many organizations have in place a system they call “Quality Assurance,” but these systems are often designed to check for adherence to quality standards at the end of the production process. TQM creates procedures for assuring quality throughout the production and service process.
- Many organizations claim to serve the customer first, but few systematically and rigorously identify the needs of customers, both internal and external, and monitor the extent to which those needs are being met.

Quality Assurance, Quality Control, Quality Audit, Quality Circles, and Quality Councils

- **Quality assurance** focuses on the front end of processes, beginning with inputs, rather than the traditional controlling mode of inspecting and checking products at the end of operations, after errors are made.
- **Quality control** is an evaluation to indicate needed corrective action, the act of guiding, or the state of a process in which the variability is attributable to a constant system of chance causes. Quality control includes the operational techniques and activities used to fulfill requirements for quality. Often, quality assurance and quality control are used interchangeably, referring to the actions performed to ensure the quality of a product, service, or process.
- **Quality audit** is a systematic, independent examination and review to determine whether quality activities and related results comply with planned arrangements, and whether these arrangements are implemented effectively and are suitable to achieve the objectives.
- **Quality circles** refer to teams of employees (6 to 12) voluntarily getting together periodically to discuss quality-related problems and issues and to devise strategies and plans to take corrective actions.
- Establishment of a **quality council** is a prerequisite of implementing a TQM program in the organization. The quality council is similar to an executive steering committee.

Concurrent Engineering

- Improved quality of design, leading to a reduction in change orders
- Reduction in product cycle time as a result of using concurrent design, rather than sequential design
- Reduction in manufacturing costs as a result of using multifunction teams to integrate product and process
- Reduction in scrap and rework as a result of product and process design optimization

Cost of Quality

The Cost of Quality (COQ) measurement identifies areas for process improvement. The focus of this measurement is to express quality in terms of quantitative and financial language, that is, costs, return on investment, cost of poor quality, cost of rework, and so on.

The COQ definition includes the following three items:

1. COQ is the cost of making a product conform to quality standards (i.e., quality goods).
2. COQ is the cost of not conforming to quality standards (i.e., waste, loss).
3. COQ is a combination of item 1 and 2.

COQ = The cost of conformance (A) + The cost of nonconformance (B)

Where (A) includes cost to prevent and detect a failure and (B) includes cost to correct a failure.

Prevention Costs

These costs are associated with all the activities that focus on preventing defects. It is the cost of conformance to quality standards.

Appraisal Costs

These costs are associated with measuring, evaluating, or auditing products to assure conformance with quality standards and performance requirements.

Failure Costs

These costs are associated with evaluating and either correcting or replacing defective products, components, or materials that do not meet quality standards. Failure costs can be either internal failure costs that occur prior to the completion or shipment of a product or the rendering of a service, or external failure costs that occur after a product is shipped or a service is rendered.

Quality Metrics

Quality metrics can be developed for the cost of quality measurement to help managers monitor quality.

- The total cost of quality as percentage of revenue by year
- The cost of conformance as percentage of total cost of quality
- The cost of nonconformance as percentage of total cost of quality

Quality Tools

Either an auditor or auditee can use quality tools. The seven old and new quality tools can be used to analyze processes, prioritize problems, report the results, and to evaluate the results of a corrective action plan.

Old seven quality control tools are traditional

1. ***Check sheets*** are used for collecting data in a logical and systematic manner.
2. A ***histogram*** is a frequency distribution diagram in which the frequencies of occurrences of the different variables being plotted are represented by bars.
3. A ***scatter diagram*** is a plot of the values of one variable against those of another variable to determine the relationship between them. These diagrams are used during analysis to understand the cause and effect relationship between two variables. Scatter diagrams are also called correlation diagrams.
4. A ***Pareto diagram*** is a special use of the bar graph in which the bars are arranged in descending order of magnitude. The purpose of Pareto analysis, using Pareto diagrams, is to identify the major problems in a product or process, or more generally, to identify the most significant causes for a given effect. This allows a developer to prioritize problems and decide which problem area to work on first.

Quality Tools (continued)

5. A ***flowcharting*** tool can be used to document every phase of a company's operation, for example, from order taking to shipping in a manufacturing company. It will become an effective way to break down a process or pinpoint a problem. Flowcharting can be done at both the summary level and the detailed level serving different user needs.

6. One form of a ***cause-and-effect (C&E) diagram*** is used for process analysis when a series of events or steps in a process creates a problem and it is not clear which event or step is the major cause of the problems. Each process or subprocess is examined for possible causes; after the causes from each step in the process are discovered, significant root causes of the problem are selected, verified, and corrected.

7. A ***control chart*** assesses a process variation. The control chart displays sequential process measurements relative to the overall process average and control limits. The upper and lower control limits establish the boundaries of normal variation for the process being measured.

New seven quality management tools are modern

1. An ***affinity diagram*** is a data reduction tool in that it organizes a large number of qualitative inputs into a smaller number of major categories. These diagrams are useful in analyzing defect data and other quality problems, and used in conjunction with cause-and-effect diagrams or interrelationship digraphs.

Quality Tools (continued)

2. A ***tree diagram*** can be used to show the relationships of a production process by breaking it down from few larger steps into many smaller steps. The greater the detail of steps, the better simplified they are. Quality improvement actions can start from the right—most of the tree to the left-most.

3. A ***process decision program chart*** is a preventive control tool in that it prevents problems from occurring in the first place and mitigates the impact of the problems if they do occur. From this aspect, it is a contingency planning tool. The objective of the tool is to determine the impact of the "failures" or problems on project schedule.

4. A ***matrix diagram*** is developed to analyze the correlations between two groups of ideas with the use of a decision table. This diagram allows one to systematically analyze correlations. Quality Function Deployment (QFD) is an extension of the matrix diagram.

5. An ***interrelationship digraph*** is used to organize disparate ideas. Arrows are drawn between related ideas. An idea that has arrows leaving it but none entering is a "root idea." More attention is then given to the root ideas for system improvement. The digraph is often used in conjunction with affinity diagrams.

6. ***Prioritization matrices*** are used to help decision-makers determine the order of importance of the activities being considered in a decision. Key issues and choices are identified for further improvement. These matrices combine the use of a tree diagram and a matrix diagram.

Quality Tools (continued)

7. ***Activity network diagrams*** are project management tools to determine which activities must be performed, when they must be performed, and in what sequence. These diagrams are similar to PERT and CPM, the popular tools in project management. Unlike PERT and CPM, activity network diagrams are simple to construct and require less training to use.

Plan-Do-Check-Act (PDCA) Cycle

The Deming PDCA cycle is a core management tool for problem solving and quality improvement. It can be used for planning and implementing quality improvements.

Stratification

Stratification is a procedure used to describe the systematic subdivision of population or process data to obtain a detailed understanding of the structure of the population or process. It is not to be confused with a stratified sampling method. Stratification can be used to break down a problem to discover its root causes and can establish appropriate corrective actions, called countermeasures. *Failure to perform meaningful stratification can result in the establishment of inappropriate countermeasures, which can then result in process or product deterioration in quality.*

Quality Models and Awards

A system should be put in place to allow the organization to determine systematically the degree to which product and services please customers, and focus on internal process improvement. Data should be collected on features of customer satisfaction such as responsiveness, reliability, accuracy, and ease of access. The measurement systems should also focus on internal processes, especially on processes that generate variation in quality and cycle time.

Deming Quality Model

According to Deming, good quality does not necessarily mean high quality. It is, rather, "a predictable degree of uniformity and dependability, at low cost, and suited to the market."

Deming's 14 Points for Management

1. Create constancy of purpose toward improvement of products and services.
2. Adopt the new philosophy. We can no longer live with commonly accepted levels of delays, mistakes, defective materials, and defective workmanship.
3. Cease dependence on mass inspection. Require, instead, statistical evidence that quality is built in.
4. End the practice of awarding business on the basis of price tag.
5. Find problems. It is management's job to work continually on the system.
6. Institute modern methods of training on the job.
7. Institute modern methods of supervision of production workers. The responsibility of foremen must be changed from quantity to quality.
8. Drive out fear, so that everyone may work effectively for the company.

Deming Quality Model (continued)

9. Break down barriers between departments.
10. Eliminate numerical goals, posters, and slogans for the workforce, asking for new levels of productivity without providing methods.
11. Eliminate work standards that prescribe numerical quotas.
12. Remove barriers that stand between the hourly worker and his right to pride of workmanship.
13. Institute a vigorous program of education and retraining.
14. Create a structure in top management that will push every day on the above thirteen points.

Juran Quality Model

According to Jospeh M. Juran, there are two kinds of quality: “fitness for use” and “conformance to specifications.” To illustrate the difference, he says a dangerous product could meet all specifications, but not be fit for use. He pointed out that the technical aspects of quality control had been well covered, but that firms did not know how to manage for quality. He identified some of the problems as organizational, communication, and coordination of functions—in other words, the human element.

Juran’s 10 Steps to Quality Improvement

1. Build awareness of the need and opportunity for improvement.
2. Set goals for improvement.
3. Organize to reach the goals (establish a quality council, identify problems, select projects, appoint teams, designate facilitator).
4. Provide training.
5. Carry out projects to solve problems.

Juran Quality Model (continued)

6. Report progress.
7. Give recognition.
8. Communicate results.
9. Keep score.
10. Maintain momentum by making annual improvement part of the regular systems and processes of the company.

Crosby Quality Model

According to Philip B. Crosby's definition, quality is conformance to requirements, and it can only be measured by the cost of nonconformance. "Don't talk about poor quality or high quality. Talk about conformance and nonconformance," he says. This approach means that the only standard of performance is zero defects. Crosby encourages "prevention (perfection)" as opposed to "inspection," "testing," and "checking."

Crosby's 14 Steps to Quality Management

1. Make it clear that management is committed to quality.
2. Form quality improvement teams with representatives from each department.
3. Determine where current and potential quality problems lie.
4. Evaluate the cost of quality and explain its use as a management tool.
5. Raise the quality awareness and personal concern of all employees.
6. Take actions to correct problems identified through previous steps.
7. Establish a committee for the zero defects program.

Crosby Quality Model (continued)

8. Train supervisors to actively carry out their part of the quality improvement program.
9. Hold a “zero defects day” to let all employees realize that there has been a change.
10. Encourage individuals to establish improvement goals for themselves and their groups.
11. Encourage employees to communicate to management the obstacles they face in attaining their improvement goals.
12. Recognize and appreciate those who participate.
13. Establish quality councils to communicate on a regular basis.
14. Do it all over again to emphasize that the quality improvement program never ends.

Malcolm Baldrige National Quality Award

The Malcolm Baldrige National Quality Award (NQA) is an annual award to recognize U.S. companies that excel in quality management and quality achievement. The award promotes:

- Awareness of quality as an increasingly important element of competitiveness
- Understanding of the requirements for quality excellence
- Sharing of information on successful quality strategies and the benefits derived from implementation of these strategies

European Quality Award

The European Quality Management Association has set up a European equivalent to the U.S. Baldrige program, the European Quality Award (EQA). Quality measures for EQA include: leadership, information and analysis, strategic quality planning, human resource development and management, management of process quality, quality and operational results, customer focus and satisfaction, financial results, and environmental concerns.

Six-Sigma

Six-sigma is an approach to measuring and improving product and service quality. In six-sigma terminology, a defect (nonconformance) is any mistake or error that is passed on to the customer. It redefines quality performance as defects per million opportunities (dpmo), as follows:

dpmo = (Defects per unit) × 1,000,000/opportunities for error where defects per unit =
Number of defects discovered/Number of units produced

Six-sigma represents a quality level of at most 3.4 defects per million opportunities. Its goal is to find and eliminate causes of errors or defects in processes by focusing on characteristics that are critical to customers.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION FRAMEWORK

ISO 9000 consists of a series of generic standards with appropriate guidelines published by the International Organization for Standardization (called ISO) for vendor certification programs. ISO 9000 addresses quality system processes not product performance specifications. In other words, it covers how products are made, but not necessarily how they work. ISO 9000 focuses on processes, not on products or people. It is based on the concept that one will fix the product by fixing the process. The ISO 9000 is a standard to judge the quality of suppliers. It assumes that suppliers have a sound quality system in place and it is being followed. ISO 9000 can be used as a baseline quality system to achieve TQM objectives.

ISO Certification Process

To earn ISO 9000 certification, a company must set up and document all procedures that relate to the process to be certified. These procedures can include everything from procuring and storing raw materials, to designing products, to issuing change orders on designs, to controlling inventory, to answering customer phone calls.

Benefits of ISO 9000

- Products from ISO 9000-certified suppliers are likely to be more reliable.
- When every step of a manufacturing process is documented, it is easier to spot problems and trace them back to an exact point in the manufacturing line. Problem tracking is facilitated.
- Its document-it-all approach makes it easier for users to evaluate products and services and to anticipate potential problems.
- Costs will be lower for both the manufacturer and the customer due to efficient operations. Lower design costs translate to lower product costs, which should mean lower prices for users.
- Buying products from ISO-certified suppliers can save customers the time and expense of conducting on-site visits of manufacturing facilities.
- It saves time and money by not having to test incoming parts from ISO-certified suppliers because its suppliers' procedures include testing.

Types of ISO 9000 Standards

ISO 8402. It presents vocabulary for quality management and quality assurance.

ISO 9000. It presents quality management and quality assurance standards. It serves as an introduction to the other standards in the series.

ISO 9001. It addresses quality systems. It is the most comprehensive model for quality assurance in design, development, production, installation, and servicing.

ISO 9002. It addresses quality systems and it is a model for quality assurance in production, installation, and servicing.

ISO 9003. It addresses quality systems and it is a model for quality assurance in final test and inspection.

ISO 9004. It deals with quality management and quality system elements. There are four parts in this standard.

Part 1 provides general guidelines for most of the quality system elements contained in ISO 9001, 9002, and 9003 in greater detail.

Part 2 provides guidelines for services.

Part 3 provides guidelines for processed materials.

Part 4 provides guidelines for quality improvement.

Types of ISO 9000 Standards (continued)

ISO 10005. It deals with quality management providing guidelines for quality plans.

ISO 10007. It provides guidelines for configuration management.

ISO 10011. It provides guidelines for auditing quality systems. Part 1 deals with auditing and includes first-, second-, and third-party audits. Part 2 covers qualification criteria (education, training, and experience) for quality systems auditors. Part 3 addresses management of an audit from initial planning to the closing meeting.

ISO 10012. It deals with quality assurance requirements for measuring equipment. It assumes that quality depends upon accurate measurements.

ISO 10013. It deals with guidelines for developing quality manuals. It describes the development and control of quality manuals, tailored to the specific user needs.

QS-9000. This guideline makes it easier for suppliers to do business with auto manufacturers and other original equipment manufacturers.

FORECASTING

The simplest form of forecasting is the projection of past trends called extrapolation. Model-building activities are examples of analytical techniques. A model breaks down a major problem into parts or subproblems and solves it sequentially. Models require a set of predetermined procedures. If there are no well-ordered and fully-developed procedures, there is no need to model. That is, *no procedure, no model*

A key concept in all forecasting models dealing with probabilities is the expected value. The expected value equals the sum of the products of the possible payoffs and their probabilities.

Time Series Analysis

Time series analysis is the process by which a set of data measured over time is analyzed. Decision makers need to understand how to analyze the past data if they expect to incorporate past information into future decisions. Although the factors that affect the future are uncertain, often the past offers a good indication of what the future will hold. *The key is to know how to extract the meaningful information from all the available past data.*

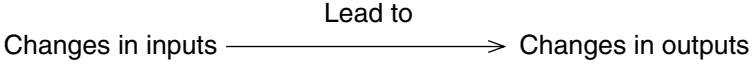
Regression Analysis

Regression analysis is a statistical technique used to measure the extent to which a change in the value of one variable, the independent variable, tends to be accompanied by a change in the value of another variable, the dependent variable.

Most measures of associations are nondirectional, that is, when calculated, it is not necessary to indicate which variable is hypothesized to influence the other. Measures of association show to what degree, on a zero-to-one scale, two variables are linked.

Sensitivity Analysis

Sensitivity analysis is an evaluation of how certain changes in inputs results in what changes in outputs of a model or system.



The primary reason that sensitivity analysis is important to managers is that real-world problems exist in a dynamic environment. Change is inevitable. Prices of raw materials change as demand fluctuates, changes in the labor market cause changes in production costs. Sensitivity analysis provides the manager the information needed to respond to such changes without rebuilding the model. For example, bank management can use the sensitivity analysis technique to determine the effects of policy changes on the optimal mix for its portfolio of earning assets.

Simulation Models

The primary objective of simulation models is to describe the behavior of a real system. A model is designed and developed and a study is conducted to understand the behavior of the simulation model. The characteristics that are learned from the model are then used to make inferences about the real system. Later, the model is modified (asking "what if" questions) to improve the system's performance. The behavior of the model in response to the "what if" questions is studied to determine how well the real system will respond to the proposed modifications. Thus, the simulation model will help the decision maker by predicting what can be expected in practice. A key requisite is that the logic of the model should be as close to the actual operations as possible. In most cases, a computer is used for simulation models.

Computer simulation should not be viewed as an optimization technique, but as a way to improve the behavior or performance of the system. Model parameters are adjusted to improve the performance of the system. When good parameter settings have been found for the model, these settings can be used to improve the performance of the real system.

PROJECT MANAGEMENT TECHNIQUES

In order for projects to be successfully implemented, they must be well managed. Many organizations apply a variety of project management techniques to optimize project success and enhance the likelihood of meeting project-specific as well as organization-wide goals. These techniques include monitoring project performance, establishing incentives to meet project goals, and developing a project management team with the right people and the right skills. This can help avert cost overruns, schedule delays, and performance problems common to many organizations.

It is important to develop **performance measures** and link project outcomes to business unit and strategic goals and objectives. The key is monitoring project performance and establishing incentives for accountability, and using cross-functional teams to involve those with the technical and operational expertise necessary to plan and manage the project.

Project Management's Basic Guidelines

- Define the objective(s) of the project.
- Establish a project organization.
- Install project controls.

Project Controls

In any project, there will be at least three types of controls applied: (1) time control, (2) cost control, and (3) quality control.

Project Organization

Project organization is where the reporting relationships and the work location rest predominantly with the project manager. Three common types of project organization include traditional structure, matrix organization, and hybrid form.

Problems in Project Management

Project managers face unusual problems in trying to direct and harmonize the diverse forces at work in the project situation. Their main difficulties arise from three sources: (1) organizational uncertainties, (2) unusual decision pressure, and (3) inadequate senior management support.

Project Scheduling Techniques

Six project scheduling techniques include program evaluation and review techniques (PERT), critical path methods (CPM), line-of-balance method, graphical evaluation and review techniques, work breakdown structure, and Gantt chart.

When PERT is used on a project, the three time estimates (optimistic, most likely, and pessimistic) are combined to determine the expected duration and the variance for each activity.

BUSINESS PROCESS ANALYSIS

In a manufacturing company, the scope of process analysis starts from raw materials and ends up with finished goods shipping to customers. It includes all the transformation (processing) stages, inspection steps, and transportation stages. Similarly, in a service company the scope of process analysis starts, for example, with claims application and ends up with making payment to the claimant. The goal of process analysis is to facilitate change for improvement. This requires looking at not only the individual processes where problems exist but also the upstream and downstream processes that are related to the process in question. Process improvements can be made by rearranging equipment layout, plant layout, inspection points, and testing stages with the help of motion study, material study, time study, and material handling studies. In this effort, both product processes and service processes should be examined for waste, delays, and improvement.

Workflow Analysis

Workflow analysis looks at the overall flow of work to find ways of improving this flow. It can reveal value-added and nonvalue-added activities (e.g., waste and delays) and identify interdependence among departments. The outcome would be eliminating the nonvalue-added activities and waste and improving efficiency and effectiveness. Assembling tasks, whether subassembly or final assembly, and process time are value-added activities of a manufactured product, while other activities are nonvalue-added activities.

Bottleneck Management

Bottleneck is a constraint in a facility, function, department, or resource whose capacity is less than the demand placed upon it. For example, a bottleneck machine or work center exists where jobs are processed at a slower rate than they are demanded. Another example is where the demand for a company's product exceeds the ability to produce the product.

Theory of Constraints

Theory of constraints (TOC) is a manufacturing strategy that attempts to remove the influence of bottlenecks on a process. According to Dr. Eliyahu M. Goldratt, TOC consists of three separate but interrelated areas: (1) logistics, (2) performance measurement, and (3) logical thinking.

Five Focusing Steps

The five focusing steps is a process to continuously improve organizational profit by evaluating the production system and the marketing mix to determine how to make the most profit using the system constraint. The steps consist of: (1) Identifying the constraint to the system, (2) Deciding how to exploit the constraint to the system, (3) Subordinating all nonconstraints to the system, (4) Elevating the constraint to the system, and (5) Returning to step 1 if the constraint is broken in any previous step, while not allowing inertia to set in.

INVENTORY MANAGEMENT TECHNIQUES AND CONCEPTS

From inventory management viewpoint, demand is of two types: independent demand and dependent demand. Independent demand inventory systems are based on the premise that the demand or usage of a particular item is independent of the demand or usage of other items. Examples include finished goods; spare parts; material, repair, and operating (MRO) supplies; and resale inventories.

Independent Demand Inventory Systems

Independent demand inventory systems are "pull" systems in that materials are pulled from the previous operation as they are needed to replace materials that have been used. An example: Finished goods are replaced as they are sold. These types of inventory systems answer the question of when to place the replenishment order and how much to order at one time. Reorder point models and fixed/variable order quantity models (e.g., economic order quantity, or EOQ) are examples of independent demand inventory systems as they do review inventory either continuously or periodically.

Dependent Demand Inventory Systems

Dependent demand inventory systems are based on the premise that the demand or usage of a particular item is dependent on the demand or usage of other items. Examples include raw materials, work-in-process inventories, and component parts.

Inventory Levels and Investment Levels

A company manages its inventory by using various methods and approaches (e.g., EOQ). Inventory consists of raw materials, work in process, and finished goods. Efficient inventory management is needed to support sales, which is necessary for profits. Benefits such as high turnover rate, low write-offs, and low lost sales can be attributed to efficient inventory management. These benefits, in turn, contribute to a high profit margin, a higher total asset turnover, a higher rate of return on investment, and a strong stock price. Inventory management is a major concern for product-based organizations (e.g., manufacturing, retail), since 20 to 40% of their total assets is inventory and as such, poor inventory control will hurt the profitability of the organization.

Efficient Inventory Management

Investment in Inventory

Investment in inventory depends on the actual level of inventory carried. The relevant question is how many units of each inventory item the firm should hold in its stock. Two types of stock concepts must be understood: (1) working stock, and (2) safety stock. The actual level of inventories carried will equal the sum of the working stocks and safety stocks.

Optimal Order Quantity

How many units should be ordered or produced at a given time is a major question faced by the inventory manager. Either too much or too little inventory is not good. An optimum inventory level is designed and is found through the use of the EOQ model. EOQ provides the optimal, or least-cost, quantity of inventory that should be ordered.

EOQ cost characteristics

- The point at which the total cost curve is minimized represents the EOQ, and this, in turn, determines the optimal average inventory level. Here, total cost is the sum of ordering and carrying costs.
- Some costs rise with larger inventories whereas other costs decline.
- The average investment in inventories depends on how frequently orders are placed.
- Ordering costs decline with larger orders and inventories due to reduced order frequency.

Optimal Order Quantity (continued)

If *Q* is the order quantity, then the how-much-to-order decision involves finding the value of *Q* that will minimize the sum of holding and ordering costs.

$$Q = EOQ = \sqrt{\frac{2D\ Co}{Ch}}$$

Where *D* is annual sales demand in units, *Co* is cost of placing one order, *Ch* is cost of holding (or carrying) one unit in inventory for the year.

Note that the data needed to calculate EOQ includes: the volume of product sales, the purchase price of the products, the fixed cost of ordering products, and carrying costs. It does not include: the volume of products in inventory, inventory delivery times, delays in transportation, or quality of materials.

Due to the square root sign, a given increase in sales will result in a less than proportionate increase in inventories, and the inventory turnover ratio will thus increase as sales grow.

Reorder Point

Another major problem facing the inventory manager is at what point inventory should be ordered or produced. The point at which stock on hand must be replenished is called the "reorder point." It is also the inventory level at which an order should be placed. The formula is

Reorder point = Lead time × Usage rate

Where lead time is the time lag required for production and shipping of inventory. Usage rate is the usage quantity per unit of time. Note: the time period should be the same in both lead time and usage rate (i.e., days, weeks, or months).

A complication in the calculation of the reorder point arises when we introduce a concept of "goods-in-transit." This situation occurs when a new order must be placed before the previous order is received. The formula for a reorder point when goods-in-transit is considered is

Reorder point = (Lead time × Usage rate) − (Goods-in-transit)

Inventory Decisions

Inventory managers face two decision rules in the management of inventories: “how-much-to-order” and “when-to-order” that will result in the lowest possible total inventory cost. The how-much-to-order decision rule can be satisfied with the use of an EOQ. This decision rule involves selecting an order quantity that draws a compromise between (1) keeping smaller inventories and ordering frequently (results in high ordering costs), and (2) keeping large inventories and ordering infrequently (results in high holding costs). The when-to-order decision rule can be satisfied with the use of a reorder point.

Calculating How Much to Order

The focus of the EOQ method is on the quantity of goods to order that will minimize the total cost of ordering and holding (storing) goods. EOQ is a decision model that focuses on the trade-off between carrying costs and ordering costs. It calculates the order quantity that minimizes total inventory costs. Calculus is used in determining the EOQ.

EOQ is appropriate for managing the finished goods inventories, which have independent demands from customers or from forecasts. The holding cost, the ordering cost, and the demand information are the three data items that must be prepared prior to the use of the EOQ model. If Q is the order quantity, then the how-much-to-order decision involves finding the value of Q that will minimize the sum of holding and ordering costs.

$$Q = EOQ = \sqrt{\frac{2D\ Co}{Ch}}$$

Where *D* is annual sales demand in units, *Co* is cost of placing one order, *Ch* is cost of holding (or carrying) one unit in inventory for the year.

EOQ Assumptions

Two major assumptions of EOQ include: (1) The demand for an item is constant. Since the constant demand assumption is not realistic, managers would have to be satisfied with the near-minimum-cost order quantity instead of a minimum-total-cost order quantity. (2) The entire quantity ordered arrives at one point in time.

Sensitivity Analysis and EOQ

It is good to know how much the recommended order quantity would change if the estimated ordering and holding costs had been different. Depending on whether the total annual cost increased, decreased, or remains the same, we can tell whether the EOQ model is sensitive or insensitive to variations in the cost estimates.

Calculating When to Order

The when-to-order decision rule is expressed in terms of a reorder point as follows:

$r = d\,m$,

Where r is reorder point, d is demand per day, m is lead time for a new order in days.

The cycle time answers how frequently the order will be placed, and it can be calculated as follows: cycle time is the number of working days in a year *divided by* the number of orders that will be placed in a year.

Safety Stock and Stockouts

Safety stock is the amount of extra stock that is kept to protect against stockouts. Running out of an inventory item is called a stockout situation. Safety stock is the inventory level at the time of reordering minus the expected usage while the new goods are in transit.

ABC Inventory Control System

ABC is a method of classifying inventory based on usage and value. Expensive, frequently used, high stock-out cost items with long lead times are most frequently reviewed in an ABC inventory control system. Inexpensive and infrequently used items are reviewed less frequently.

Effects of Inflation on Inventory Management

There is no evidence that inflation either raises or lowers the optimal level of inventory of firms in the aggregate level. It should be considered since it will raise the individual firm's optimal inventory holdings if the rate of inflation is above average, and vice versa.

Just-in-Time Systems

JIT Strategy

Just-in-time (JIT) is a production strategy to continuously improve productivity and quality. It is based on the belief that small could be better, not "more" is better. An effective JIT strategy encompasses the entire product life cycle from the acquisition of raw materials to delivery of the end product to the final customer. *The scope includes topics such as JIT purchasing, production processing, inventory, and transportation.*

JIT is based on management principles such as eliminate waste; produce to demand and one-at-a-time; think long-term; develop, motivate, trust, and respect people; and achieve continuous improvement. This is made possible when the focus is "quality at the source" and the tools used are statistical process control methods, fail-safe methods, and problem-solving methods. Quality at the source means producing perfect parts every time and all the time. The major benefits of JIT strategy are improved productivity, quality, service, and flexibility and reduced costs, inventory investment, lead times, lot sizes, and physical space.

JIT Purchasing

JIT purchasing requires a partnership between a supplier and a customer, which is a major departure from the traditional purchasing. JIT supplier relations call for long-term partnerships with single source suppliers who provide certified quality materials while continuously reducing costs. The JIT supplier's manufacturing processes must be under statistical process control and their capability should be certified by the customer. The statistical process control charts serve as the documentation to assure that the process stayed in control during the time the parts were made.

JIT Production Processing

JIT production processing requires setup reduction, focused factory, group technology, uniform scheduling and mixed model scheduling, and the pull system. The objective here is to produce many varieties of products in small quantities on short notice. Manufacturing flexibility is the hallmark of the JIT production processing strategy.

JIT Inventory

A misconception about JIT is that it is just a program to reduce inventory. Fortunately, JIT does more than that. JIT purchasing is called “stockless inventory” since the customer has no inventory to stock as it is used up in the production right after it was received. The major goal is to reduce or eliminate work in process inventory so that all raw materials are consumed in the production process.

JIT Transportation

While JIT purchasing is the starting point of a JIT cycle, the JIT transportation is the execution part of the JIT cycle. JIT transportation is the physical linkage between the inside and the outside processes. It is a process that starts at a supplier location and ends at a customer location. It requires the analysis of all transport events and eliminating the nonvalue-added events. The basic value-added events include: Move load to dock at a supplier location, load carrier, move load to customer location, return empty trailer to terminal, unload by the customer, and move load to assigned customer location.

Materials Requirements Planning

Materials requirements planning (MRP) is suitable for managing raw materials, components, and subassemblies, which have dependent demands that may be calculated from the forecasts and scheduled production of finished goods. In other words, the order for component inventory is placed based on the demand and production needs of other items that use these components.

Distribution Systems

Inventory in a distribution system can be managed through the use of independent demand models such as continuous and periodic review models. The continuous review model can be a single or double order paint system.

Single Order Point System

The single order point system basically ignores the fact that the order takes place in a chain and assumes that each element in the distribution system is independent of all other components. This independent behavior can cause large swings caused by a phenomenon called “lumpy demand” at the next level down in the distribution chain. The lumpy demand comes from the lack of communication and coordination between the factory, warehouse(s), distributors, and retailers.

Double Order Point System

The double order point system considers two levels down in the distribution system, hence the name “double.” For example, if a distributor is quoted a lead time from the factory warehouse of two weeks and it takes the factory warehouse three weeks to have stock replenished, the reorder point is set based on the demand for a five-week period. It does not produce lumpy demand, as does the single order point system. An advantage is that it reduces the risk of stockouts. Increasing the safety stock is its disadvantage.

Periodic Review System

In a periodic review system, orders are placed on a predetermined time schedule. The advantage is that the order times can be staggered throughout the chain to smooth the demand at each point in the distribution chain. This reduces peaks and valleys caused by several customers ordering at the same time.

Sales Replacement System

In the sales replacement system, the supplier ships only what the customer used or sold during the period. The objective is to maintain a stable inventory level in the system. This does require having enough inventory to cover the potential demand during the replenishment cycle. In essence, the sales replacement system is a periodic review model with variable order quantities.

Distribution Requirements Planning

Distribution requirements planning (DRP) is an application of the time-phasing logic of MRP applied to the distribution system. The purpose of DRP is to forecast the demand by distribution center to determine the master production scheduling needs. It uses forecasts and known order patterns from customers in the distribution chain to develop the demand on the master schedule.

Inventory Distribution Methods

The functions of warehouse distribution, production, and purchasing are closely interrelated and constantly interacting with each other in a manufacturing firm. The decision problems considered during inventory distribution strategy are when, what, and how much of it to ship to a warehouse; when, what, and how much of it to produce at the factory, with what size workforce; and when, what, and how much of it to purchase as inputs to the factory warehouse system.

Warehouse Inventory Control

Warehouses usually stand in a distribution system between a factory and final customers or other warehouses.

Types of Warehouse Shipments

Warehouses usually stock a very large number of products—the larger the shipment size, the more products are involved, and the greater are the problems of controlling the inventories of different products jointly. These are some of the considerations involved in decisions to order shipment to warehouses. Two basic types of shipments can take place: (1) periodic shipments, and (2) trigger shipments.

Other Warehouse Considerations

In estimating the cost of alternative shipping carriers, the cost of having valuable inventory tied up while the vehicle is in transit should be considered. While this cost will usually not be large, taking it into account will systematically lower the costs of using faster rather than slower carriers. Another economy associated with fast shipments that may be overlooked is the fact that time in transit is one component of the lead-time. *Shortening the lead-time allows a reduction in the inventory buffers, and hence a decrease in inventory holding costs.*

MARKETING: PRICING OBJECTIVES AND POLICIES

Pricing Objectives

Pricing decisions that integrate the firm's costs with its marketing strategy, business conditions, competition, consumer demand, product variables, channels of distribution, and general resources can determine the success or failure of a business. Pricing of products or services is the cornerstone of the marketing function. *If the price is too high, buyers may purchase competitive brands leading to a loss of sales and profits. If the price is too low, profitability may suffer despite increases in sales.*

General Pricing Decision Model

Pricing decisions require the consideration of many factors. A nine-step pricing decision model includes: (1) define target markets, (2) estimate market potential, (3) develop product positioning, (4) design the marketing mix, (5) estimate price elasticity of demand, (6) estimate all relevant costs, (7) analyze environmental factors, (8) set pricing objectives, and (9) develop the price structure.

MARKETING: SUPPLY CHAIN MANAGEMENT

The supply chain is seen as equivalent to an input-transformation-output system. In this context, both customer and supplier goodwill are to be viewed as key assets to an organization. The supply chain becomes a value chain when all of the transforming activities performed upon an input provide value to a customer. The real challenge is to ensure that value is added at every step of the chain to achieve customer satisfaction. Both purchasing and the supplier play a large role in the value chain.

Managing the supply base includes integration of suppliers, involvement of suppliers, supplier reduction strategies, supplier performance, and supplier certification. The purpose of managing the supply base is to manage quality, quantity, delivery, price, and service.

Alternative Market Channels

It takes a considerable amount of time, money, and effort to set up channels of distribution. Because of this heavy commitment of resources, once decisions are made about the channel of distribution they are not easy to retract. Yet these decisions are very critical to the success of the firm. Decisions based on inaccurate or incomplete information can be very costly to the firm. Whether it is a consumer good or industrial good, channels of distribution provide the ultimate consumer or industrial user with time, place, and possession value (utility). *Thus, an efficient channel is one that delivers the product when and where it is wanted at a minimum total cost. Marketing intermediaries exist to bring about product exchanges between buyers and sellers in a reasonably efficient manner.*

Marketing Intermediaries

The primary role of intermediaries is to bring supply and demand together in an efficient and orderly manner.

Channels of Distribution

A channel of distribution is the integration of intermediaries through which a seller markets his products to users or consumers. Agents, wholesalers, and retailers are called intermediaries. These intermediaries are also called middlemen. Channels with one or more intermediaries are referred to indirect channels. In addition, the choice of channels can be improved by considering distribution coverage required, degree of control desired, total distribution cost, and channel flexibility.

Selecting Intermediaries

*The two basic methods of selecting intermediaries (middlemen) are **pushing** and **pulling.*** Pushing a product through the channel means using normal promotional effort—personal skills and advertising—to help sell the whole marketing mix to possible channel members. This is a common approach with the producer working through a team to get the product to the user. By contrast, pulling means getting consumers to ask intermediaries for the product. This involves distributing samples and coupons to final consumers. If the promotion works, the intermediaries are forced to carry the product to satisfy their customer needs.

Managing Channels of Distribution

From a management point of view, entire channels of distribution should be treated as a social system since each party plays a defined role and each has certain expectations of the other. The interaction with each other is very critical for all parties involved and the behavioral implications are many.

A policy is a statement of how an organization intends to handle an issue or a situation. A policy statement can be brief or expanded. A key element of a policy is that it is a predetermined guideline providing a specified course of action for dealing with prescribed circumstances. Some organizations operate without written policies because they want to handle issues on a case-by-case basis. Employees may see this as a way to show favoritism or discrimination. Unwritten practices tend to become informal policies causing confusion and chaos.

Two choices are available for companies who want to develop written policies: (1) develop policies on a department level or (2) an organization level. Policies developed at the individual department level could create conflicting practices for common items such as attendance, promotions, vacations, sick leave, and employee discipline, leading to low productivity and high morale problems.

Policies developed on an organization level would provide: consistency in handling similar issues, improved communication of policy issues, control over personnel costs, prevention or response to administrative claims and litigations, compliance with government laws and regulations, and delegation of routine personnel decisions to supervisors and managers.

Recruiting Policy

A human resource policy on recruiting will guide managers to hire the right person for the job. The primary purpose of the recruiting policy is to attract qualified candidates at a minimum cost and time. A recruiting policy will also enable the organization to contact a diverse variety of recruiting resources, which helps to avoid charges of bias in recruiting practices.

Employee Selection Policy

Careful employee selection is an important activity because capable, hardworking employees affect the productivity and profitability of the organization. This involves employee screening, testing, physical exam, and orientation. Costs are incurred during selection, termination, and rehiring.

Equal Employment Opportunity Policy

A policy statement asserting equal employment opportunity, by itself is not enough to prevent discriminatory practices. Since equal employment laws cover all employment decisions, specific guidelines are needed to guide managers in effectively implementing this policy.

A policy on equal employment opportunity must accomplish a variety of purposes. It must identify protected class employees, specify covered employment decisions, outline guidelines for managers, provide a mechanism for individuals to present claims, and define procedures for resolution of those claims.

Transfers and Promotions Policy

Employee transfers can occur between jobs, work locations, operating shifts, or departments. Transfers may be initiated by the organization to move an employee to another assignment in response to staffing requirements. Employees may also request transfers. Transfers may be temporary or permanent.

Performance Appraisals Policy

A performance appraisal is a structured discussion between employee and supervisor. It provides an opportunity for the supervisor to recognize an employee's achievements, offer suggestions for improvement when needed, discuss job responsibilities, define job objectives, counsel on career advancements, and justify a pay adjustment.

A policy on performance appraisals provides guidelines for managers to conduct effective performance appraisal. The policy can identify when performance appraisals should be scheduled, who is responsible for preparation of the appraisal, how the appraisal influences pay adjustments, and how to prepare for and conduct performance appraisals.

Pay Administration Policy

A pay administration policy provides instructions to aid supervisors in understanding the organization's compensation philosophy, formulating pay offers, and having salary adjustments. Further, it can define guidelines which allow supervisors to make pay decisions within prescribed limits. Exceptions to pay policy can be referred to human resources management for approval.

Bonus Incentives Policy

Many organizations have considered bonus or incentive pay plans as a way to stimulate desired improvements in productivity and quality levels. The goal of a bonus incentive plan is to reward employees for achievement of specified performance results. It is a win-win situation—the employees benefit from higher compensation based upon their attainment of plan objectives. The employer benefits because increased productivity (or lower costs) promotes higher profits. A good bonus plan should pay for itself.

Varieties of incentive pay plans follow. Premium pay is used by some firms to provide an incentive for certain kinds of work. Premium pay is added to the employee's base pay when certain specified conditions are met. Piece rate is often used in manufacturing firms where employee productivity is measured by the number of pieces produced. Many sales people are compensated on a commission basis. The commission is a designated percent of the selling price or profits on the items sold. Bonus incentives can be an informal payout to employees after a profitable year based on management discretion.

Wage Garnishments Policy

Wage garnishments are a court-ordered process for an employer to withhold a portion of an employee's earnings for payment of a debt. Therefore, the garnishments impose a legal obligation upon the employer. An employer's failure to withhold monies as directed could create financial obligations on the company. Further, failure to properly handle deductions can create legal liabilities for the firm. For these reasons, it is important to define a policy to guide the handling of wage deduction orders.

There are a variety of wage deduction orders: tax liabilities (back taxes) to tax authorities, spouse or dependent (child) support payments, and creditors based on wage assignment agreement when granting credit.

The Consumer Credit Protection Act is one law that defines employer obligations relating to wage garnishments. The Act prohibits employers from discharging an employee whose earnings have been subjected to any indebtedness. Further the law limits the amount of an employee's wages that can be subject to garnishments.

The Hatch Act, amended in 1994, requires federal agencies to honor court orders for withholding amounts of money from an employee's wages, and to make payment of that withholding to another person or organization for the specific purpose of satisfying a legal debt of the employee. The total debt can include recovery of attorney's fees, interest, or court costs.

Records Retention Policy

Federal government labor laws, wage hour laws, and many similar state laws specify certain minimum records that must be maintained by employers. These laws define minimum records retention requirements. Some states have laws that deal with the issues of personnel records privacy and employee access to personnel files.

Safety Policy

Firms that have successful safety programs typically share three common characteristics: a management commitment to safety, active employee participation in safety activities, and thorough investigation of accidents. Successful safety programs reduce accidents. Fewer accidents mean less work interruptions, fewer worker's compensation claims, and lower insurance costs.

The U.S. Occupational Safety and Health Administration (OSHA) is the federal government agency responsible for defining and enforcing job standards. The OSHA law covers all employers engaged in a business affecting commerce, but excludes self-employed individuals, family firms, and workplaces covered by other federal safety laws. Employers covered by OSHA have a general duty to maintain a safe and healthful workplace. The general duty requirements mean that the employer must become familiar with safety standards that affect the workplace, educate employees on safety, and promote safe practices in the daily operation of the business.

BALANCED SCORECARD SYSTEM

Most businesses have traditionally relied on organizational performance based almost solely on financial or accounting-based data (e.g., return on investment and earnings per share) and manufacturing data (e.g., factory productivity, direct labor efficiency, and machine utilization). Unfortunately, many of these indicators are inaccurate and stress quantity over quality. They reward the wrong behavior; lack predictive power; do not capture key business changes until it is too late; reflect functions, not cross-functional processes; and give inadequate consideration to difficult-to-quantify resources such as intellectual capital. Most measures are focused on cost, not so much on quality.

Kaplan and Norton (*The Strategy-Focused Organization*, Harvard Business School Press, 2001) of Harvard Business School coined the term "balanced scorecard" in response to the limitations of traditional financial and accounting measures. They recommend that key performance measures should be aligned with strategies and action plans of the organization. They suggest translating the strategy into measures that uniquely communicate the vision of the organization. Setting targets for each measure provides the basis for strategy deployment, feedback, and review.

The balanced scorecard system is a comprehensive management control system that balances traditional financial measures with nonfinancial measures (e.g., customer service, internal business processes, organization's capacity for innovation and learning, and manufacturing). This system helps managers focus on key performance measures and communicate them clearly throughout the organization.

Measures

Measures should include both financial and nonfinancial. Financial measures include ROI, residual income, earnings per share, profit, cost, and sales. Nonfinancial measures include customer measures, internal business process measures, innovation and learning measures, and manufacturing measures. Customer measures include satisfaction, perception, and loyalty. Internal business process measures include efficiency, quality, and time. Innovation and learning measures include research and development (R&D) investment, R&D pipeline, skills and training for employees, and time to market a product or service. Manufacturing measures include factory productivity, direct labor efficiency, and machine utilization.

Indicators

A good balanced scorecard system contains both leading and lagging indicators, and both financial and nonfinancial measures. For example, customer survey (performance drivers) about recent transactions might be a leading indicator for customer retention (a lagging indicator); employee satisfaction might be a leading indicator for employee turnover (a lagging indicator), and so on. These measures and indicators should also establish cause-and-effect relationships across all perspectives. The cause-and-effect linkages describe the path by which improvements in the capabilities of intangible assets (people) get translated into tangible customer satisfaction and financial outcomes.