Forecasting

3

Unit Introduction

Forecasting - one of the key elements of operations management. It tells us what the customer will need at what time and in which quantity. It relates the management functions of planning, organizing and controlling. Company serves their customers and the society at large by producing various goods and services in factories and plants. The market needs for such products are changing. And their suppliers have to respond more quickly than ever before with product delivery to survive. To do so, they have to place a higher emphasis on forecasting to determine the demand level. Otherwise, if a firm produces less than the actual demand, customers will go unsatisfied and if they produce more, unsold products will pile up. Forecasting, done by using data from past events or through some subjective judgment (like experience, guesses, hunches, etc.) and reduces severity of any unexpected events. If firm knows how much to produce, it can plan and organize operations accordingly. And if operations have been properly planned and organized, control is easier and smoother. This is where forecasting comes in. Thus forecasting also reduces the costs of adjusting operations in response to unexpected deviations by specifying future demand. Furthermore it helps improve the organization's competitive edge. Keeping this entire in mind, the following lessons are covered in this unit: Products and Forecasting; Different Elements of Forecasting; and Different Approaches and Techniques of Forecasting.

Lesson One: **Product and Forecasting**

Lesson Objectives

After completing this lesson you will be able to:

- Understand the meaning of forecasting and its importance
- Identify the subjects of forecasting
- Explain the factors that affect the product demand of forecasting
- Discuss how to develop a workable forecasting system

Forecast and its Implications

The term *Forecast* can have different meanings in different disciplines (e.g., business, economics, and political communities). In operations management, we rather adopt a specific definition of *forecast*, distinguishing it from the broader concept of *prediction*. Therefore a forecast is an inference of what is likely to happen in the future. It is estimated by systematically combining and casting forward data about the past in a predetermined way. It is objective in nature but not an absolutely certain prophesy. Even very carefully prepared forecasts can be wrong. In fact, it is extremely rare for a forecast to be exactly right. A prediction, on the other hand, is an estimate of a future event achieved through subjective considerations other than just past data. In case of prediction subjective consideration need not occur in any predetermined way. Therefore the implications of forecasting and/or prediction are:

Forecast is an inference of what is likely to happen in the future.

- *Forecasting is both objective and subjective:* As noted, forecasting is the art and science of predicting future events, which may involve taking historical data and projecting them into the future with some sort of mathematical model. It may be subjective or intuitive prediction of the future or it may be of both, i.e., a combination of mathematical models adjusted by good judgment. As definitions make clear, forecasts are possible only when a history of data exists and reasonable inferences can be reached on the basis of that data. For example, a canteen manager can use past data to forecast the number of a regular product like tea, but suppose s/he wants to offer a new product—black coffee. Since no past data exists to estimate the sales of the new product, prediction, instead of forecasting, will be needed.

Forecasts are possible only when a history of data exists and reasonable inferences can be reached on the basis of that data.

- *Forecasting prepares an organization for a common future objective through coordination:* Forecasting helps develop and implement a c*ontinuous improvement program* specially tailored for any particular business and organization culture and environment. It is an aid to other program which may involve implementation of proven manufacturing and distribution planning and control tools and techniques such as *Manufacturing Resources Planning (MRP)*, *Distribution Resources Planning (DRP)* and *Just-In-Time (JIT).* In forecasting, demand and sales forecasting in particular, is essential to the three major activities of any operations manager that are planning, scheduling and controlling the system (Figure 3.1.1). Demand forecast drives the production capacity and scheduling system in a firm and affects the financial, marketing and HR or personnel planning functions. So, forecasting is not only the critical part of operations manager's function but also important to financial, marketing and HR manager. Thus, it brings every department together and strengthens corporate culture and environment. Forecasts provide a basis for coordination of plans for activities in various parts of a company. When all parts of the company base their work on the same forecasts, they prepare for the same future and their efforts are mutually supportive. In other words, co-ordination of activities is accomplished when adequate forecasts prepare an organization for a common future objective.

Forecasting is important for designing the long term as well as for the short term decision making.

- *Forecasting aids in both short-term and long-term planning.* Forecasts are important inputs for long-range planning and strategic decisions. At the same time they are an important basis for shorter-range decisions in day-to-day operations. Operations managers try to forecast a wide range of future events that potentially affect success. Most often the concern is forecasting *customer demand* for products or services. Managers may want long-run estimates of overall demand or short-run estimates of demand for each individual product. Businesses must develop forecasts of the demand level, which the company should prepare to meet. Since service operations generally cannot store their output as inventory, they must try harder to estimate the level of future demand. When service organizations fail to accurately forecast their demands, they often face a double-edged sword. Overstaffing leading to waste and non-optimal operation on one hand and understaffing resulting in loss of business, time and customers on the other.

Activity: Assume you want to start a garment business. Now, how the forecasting techniques can help you to be successful in that business.

Subjects of Forecasts

A successful operation plan must inference about economic, technical and demand forecast.

In making decisions, managers need to make inferences about the future in several subject areas. Such three relevant areas are *technological developments, business conditions,* and *the expected level of demand.* With respect to these, organizations use three major types of forecasting in planning the future of their operations. These are, economic, technological and demand forecasting. Figure 3.1.1 depicts these three different kinds of forecast in organizational setting:

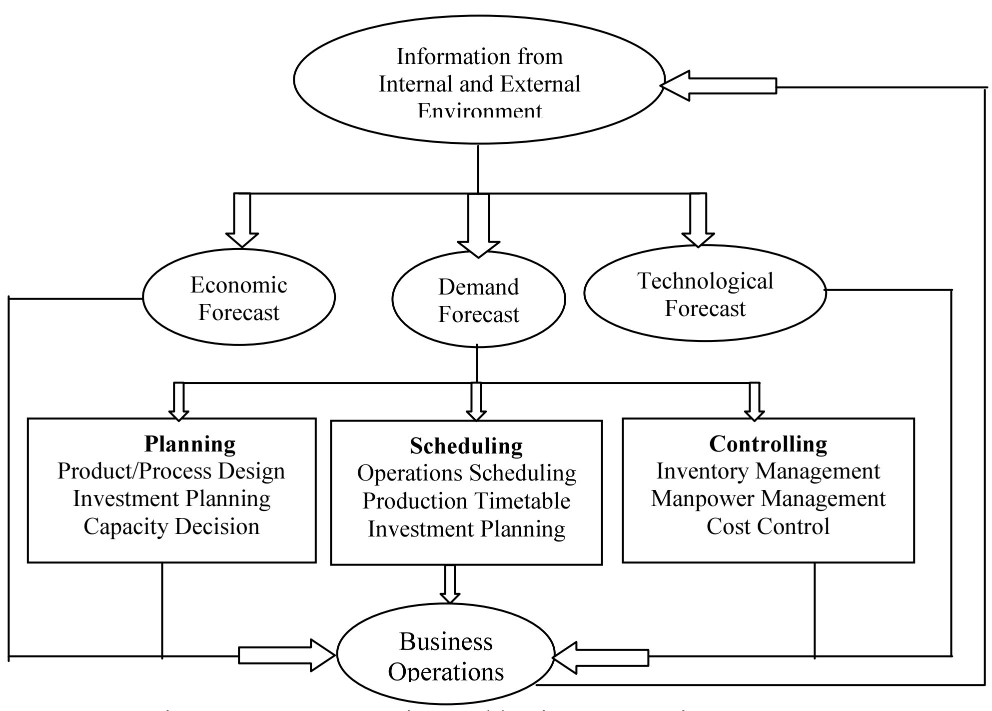

Figure 3.1.1: Forecasting and business operations

Economic forecasts address the business cycle by predicting inflation rates, money supplies, recession, infrastructure, housing and other planning indicators. Businesses can gain useful ideas about the expected long and intermediate range business conditions and business growth from such forecasts. Fiscal policy and monitory policies are also considered in economic forecasting.

Technological forecasts are concerned with rates of technological progress, which can result in the birth of innovative products requiring new plants and equipment. Technological changes provide many businesses with new products and materials to offer, new methods to be implemented, while some businesses with obsolete products and/or processes fail in the face of the competition. Forecasts about technological developments are very important for businesses in dynamic fields like computer technology, telecommunications services etc.

Technological forecasts are concerned with technological changes in business environment.

Demand forecasts are projections of anticipated level of demand for a company's products or services. These forecasts are also called the sales forecast. Demand forecasts are very important instruments for planning and monitoring decisions. In effect, the whole of operations management is guided by demand forecasts of goods and services. The discussions of this text are generally guided towards forecasting demand.

Demand forecast is often called the sales forecast.

Factors Affecting Product Demand Forecast

Demand forecast is given much importance in operations management. Operations managers most often have to forecast customer demand for their products or services. Managers may need long-run estimations of overall demand or short-run estimates of demand for individual products. So, they have to know what factors are responsible for a particular product's demand.

Operations manager often have to forecast customer demand to know– what factors are responsible for their product demand.

Demand of a particular product of a particular company, as you know, is a result of many forces in the market, like average income of the consumers, price and availability of related goods, to name a few (Figure 3.1.2). Basically, however, it depends on the size of the market of that product and the share of the market that the company captures. A number of forces that are beyond the company's control, as well as others that the company can at least influence, act to determine the level of demand that the company receives. Examples of such forces are environmental factors, political and legal happenings etc.

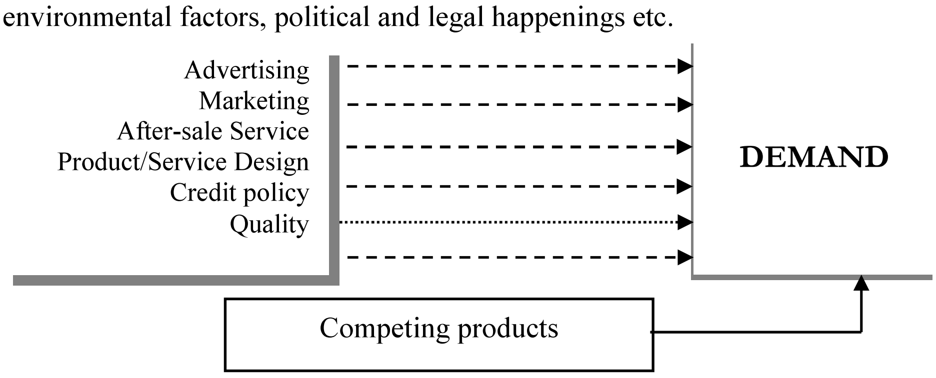

Figure 3.1.2: Variables affecting demand for product or service

Status of Economy

Sales are influenced by demand and demand is influenced by a large number of factors. One factor that influences demand is the *status of the economy.* As the *business cycle* goes through the phases of *depression, recovery*, and *boom*, demand shifts and changes accordingly (Figure 3.1.3). The following actions will discuss these influential factors of the business cycle.

When the economy moves into recession, output and income fall resulting into a fall in consumption and investment.

Economic activity is at a low in comparison with surrounding years.

- **Recession:** The contractionary phase of the trade cycle which follows a *peak* and ends with the *trough*. The term recession is generally reserved for the mild version of this phase, unlike the *slump*, which is a severe version. If the underlying growth rate of output (or income) is sufficiently positive, a recession may be marked by a fall in the growth rate with no absolute fall in output. When the economy moves into recession, output and income fall resulting into a fall in consumption and investment. Tax revenues also begin to fall and government expenditure on benefits begins to rise. Wage demands are moderate as unemployment rises. Imports decline and inflationary pressures ease.
- **Depression:** It is the severe downturn phase in the business cycle. Any contractionary phase of the trade cycle could be called a depression but the term is usually reserved for the most severe cases, such as the downturn in output in the USA and Europe in particular which occurred in 1929 and the years following (the great depression). Economic activity is at a low in comparison with surrounding years. Mass unemployment exists, so, consumption, investment and imports will be low. There will be few inflationary pressures in the economy and prices may be falling.
- **Recovery:** The expansionary phase of the trade cycle during which output begins to increase. Recovery follows a *trough* and ends with the *peak*. In this period national income and output begin to increase. Unemployment falls. Consumption, investment and imports begin to rise. Workers feel more confident about demanding wage increases and inflationary pressures begin to mount.
- **Boom:** The expansionary phase of the trade cycle. The term is usually only applied to particularly fast rates of upward divergence from the secular trend. National income is high during boom period. It is likely that the economy will be working at beyond full employment. Consumption and investment expenditure will be high. Tax revenue will be high. Wages will be rising and profits increasing. The country will be sucking in imports demanded by consumers with high incomes and businesses with full order books. There will also be inflationary pressures in the economy.

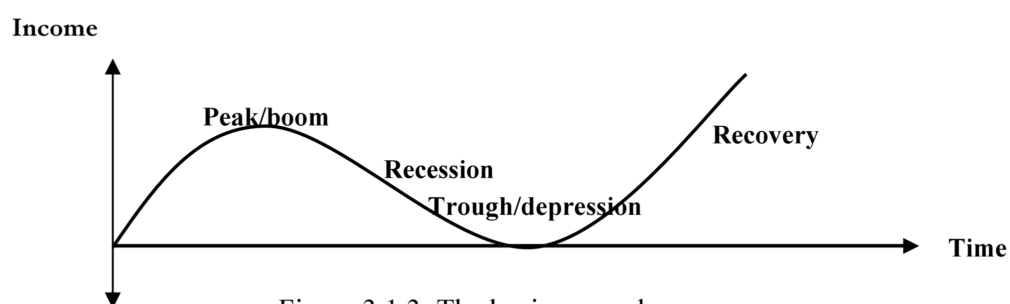

Figure 3.1.3: The business cycle

- **Inflation:** Inflation is a sustained rise in the general price level. The inflation may be Demand pull or Cost push. *Demand-pull inflation* is caused by excess demand in the economy. Output increases and unemployment decreases in such case. *Cost-push inflation* is caused by increases in the costs of production in the economy. Such impulse leads to a drop in output. However, unemployment *may not* decrease. During an inflationary period, prices of some products (for example, food) rise faster than others, inducing diversions of resources to those sectors. Inflation adversely affects the standard of living by reducing the purchasing power of income, especially of those who are on fixed incomes, such as pensioners. Similarly, it adversely affects lenders. If, households expect prices to be higher in the future, they will be tempted to bring forward their purchases. However, rising inflation tends to reduce consumption. The negative effect on consumption more than offsets the positive effect on consumption caused by the bringing forward of purchases.

Inflation adversely affects the standard of living by reducing the purchasing power of income.

Government actions and reactions like careful use of monetary (i.e. determining supply of money and interest rates) and fiscal policies (i.e. taxation and spending) are intended to mitigate the severity of the variations of business cycle. However constant change in demand is still a fact of life in much of the business world.

Activity: Do you think product demand of forecast of your business will be affected by the socio-economic factors? Justify.

The Product Life Cycle (PLC) and Forecasting

Products are born, they live, and they die. They are cast aside by a changing society. Normally, a product passes through five stages in its *product life cycle*: (i) Development, (ii) Introduction, (iii) Growth, (iv) Maturity or Steady state, and (v) Decline or Phase out (Figure 3.1.4)[1]. (*also discussed in the unit one lesson 2*).

i. *Product development*: Product development begins when the company finds and develops a new product idea. During product development, sales are zero and company's investment cost add up.
ii. *Introduction*: A period of fluctuating and slow sales growth as the product is introduced in the market. Profit is nonexistent in this stage because of the heavy expenses of product introduction.
iii. *Growth*: A period of rapid market acceptance and substantial profit improvement.
iv. *Maturity*: A period of stability and slowdown in sales growth because the product has achieved acceptance by most potential buyers. Profit stabilizes or decline because of increased marketing outlays to defend the product against competition.
v. *Decline*: The period when sales show a downward drift and profits erode.

A product, whether good or service, cannot reach the same percentage of population or target market every day of its existence. Lets think about the products various stages of the life cycle in the music industry- Digital audio tapes are in the introductory stage, compact disk are in the growth stage, cassettes are in the maturity/saturation stage, and eight track tapes are in the decline stage.

[1] In many cases we combine development, and testing and/or introduction as one stage.

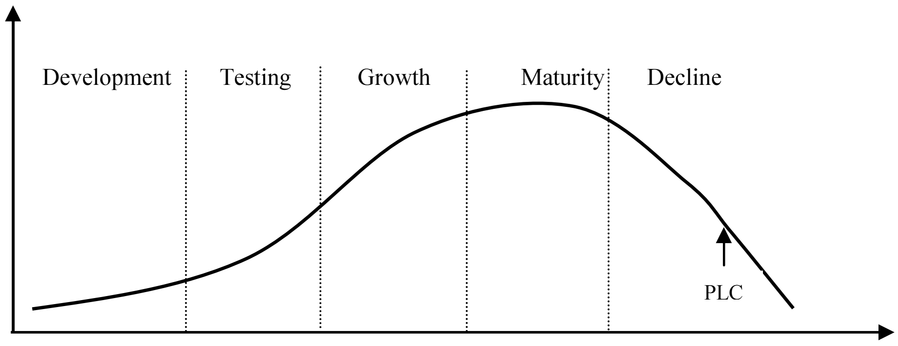

Figure 3.1.4 The product life cycle (PLC)

Products in the first two stages of their life cycle need longer forecasts than in the maturity and decline stages.

Hence the operations manager need to carefully analyze the PLC of any product during sales forecast, especially for the longer ones. However, products in the first two stages of their life cycle need longer forecasts than that of those in the maturity and decline stages. Again introduction and growth stages are quite turbulent with gradual increase in sales. While at maturity the demand reaches a steady state and finally starts to decline. The forecasting are also useful in projecting different staffing levels, inventory levels, and factory capacity as the product passes from the first to the last stage.

A large number of other factors influence demands particularly when one considers secondary influences, that is, factors that affect the customer's demand for goods and services, which in turn affects the demand for the company's product or service. These can be ethical issues, consumer association, competitors' actions, consumers' preferences, and other social phenomena.

Uses of Forecasting

Forecasting is often used in organizations for three purposes. These are,

- *New output introductions:* Forecasting is used to decide whether environmental demand is sufficient to generate the returns desired by the organizations. If demand exists but at too low a "price" to cover the "costs" the organization will incur in producing the output then the organization should reject the opportunity.
- *Capacity needs:* Forecasting is used to determine long time capacity needs for facility design. An accurate projection of demand for a number of years in the future can save the organization great expense in expanding, or contracting, capacity to accommodate future environmental demands. Due to competitive forces in the environment, even in the non-profit sector, an organization that produces inefficiently, because of excess idle capacity, or insufficiently to meet demand, is courting disaster.
- *Production planning:* Forecasting is used to ascertain short-term fluctuation in demand for production planning, workforce scheduling, materials planning, and so forth. These forecasts are of special importance to operations management and crucially affect operational productivity, bottlenecks, master scheduling, meeting promised delivery dates, and other such issues of concern to top management and the organization as a whole.

How to Develop a Workable Forecasting System?

In the organization production personnel, inventory control personnel, and marketing personnel should cooperate in determining the forecast. This cooperation provides checks and balances for the forecasting procedure. In order to create a workable forecasting system, it is best to assign specific responsibilities as follows:

- The marketing people should forecast only product groups or promotion items and items for which a definite trend is expected or has been detected.
- Production and inventory management people should be responsible for tracking forecasts, and for reporting deviations of a significant magnitude to the marketing people for interpretation.
- Transformation of sales forecasts into production plans should be done by production and inventory control management, since, in order to level the capacity requirements, the production plan will not necessarily follow the sales forecast.
- The expeditious interpretation of deviations from forecast, when reported, is the responsibility of the marketing people. Unless an interpretation has been put forward and revision is required by the marketing people, production and purchasing will not stop.

In other words, a workable forecasting system is a system in which production, inventory and marketing personnel work together, in a coordinated effort, from the initial forecast, through actual production, down to forecasting revision, as required.

Need for Judgment in Forecasting

Forecasting, as we have seen, is an art or a special skill rather than an exact science. The key inputs in a science are constant laws of nature, whereas the key inputs of forecasting are information, analysis, experience, and informed judgment. There are no natural laws that make the relationships between demand and other variables continue to behave as they have done in the past. Economic conditions, competitors' actions, consumers' preferences, and other social phenomena often are whimsical. Judgment must be exercised to see that appropriate forecasting methods are developed and properly applied. In an organization judgment is used to determine what data to collect for possible evaluation and use in forecasting. A forecaster must exercise judgment in evaluating tabulated data and graphs to discern whether there is some pattern to demand or whether changes in demand appear to be related to some factors that can be identified and used to forecast future changes in demand.

> Judgment must be exercised to see that appropriate forecasting methods are developed and properly applied.

Often in the business world a purely subjective approach is used by the operations managers, where the forecaster forms an opinion of the relative influences of many factors on demand and estimates the resulting demand. For example, in a subjective approach called *jury of executive opinion* where a group of executives make subjective forecasts relying on experience, intuition and personal understanding. Even if a mathematical model of forecasting is used, one must still decide which variables to evaluate in developing it and which of many possible equations to use.

> 'Jury of executive opinion' where a group of executives make subjective forecasts relying on experience, intuition and personal understanding.

On the contrary, if a quantitative measure of forecast is used to evaluate possible models, judgment must be used to select the appropriate measure, because often they point to different models as being the best. For instance, a manager may face a dilemma when they try to choose between exponential smoothing and moving average (explained in detail in lesson Three) to forecast a certain product's demand. Here only statistical techniques like forecasting errors may not be enough to make a decision.

For as long as the model is used, someone should judge whether the model that was developed is appropriate for the purpose for which it was developed. Because it is important to see if the demand data of past periods is still appropriate to use for current and expected future conditions. That is whether the same forces are still acting on demand, whether they are exerting the same relative influence, and whether they can be expected to continue to do so. In some cases, forecasters may also develop versatile models that will adapt to changing conditions.

Summary

Forecasting is one of the key elements of operations management. A forecast is an inference of what is likely to happen in the future. It is estimated by systematically combining and casting forward in a predetermined way data about the past. Forecasting involves taking historical data and projecting them into the future with some sort of mathematical model. It may be subjective or intuitive prediction of the future or it may be both, i.e., a combination of mathematical models adjusted by good judgment. But a history of data must exist from which reasonable inferences can be reached for forecasting. Forecasting prepares an organization for a common future objective through department activity co-ordination. It is important for both short-term and long-term planning.

Organizations use three major types of forecasting (economic, technological and demand forecasting) in planning the future of their operations. All forecasts lead to demand forecasting. Demand of a particular product of a particular company is a result of many forces in the market, like average income of the consumers, price and availability of related goods. Basically, it depends on market size of that product and the captured market share of that company. A number of forces that are beyond the company's control (environmental factors, political and legal happenings), as well as others that the company can at least influence (Product life cycle), act to determine the level of demand that the company receives. To develop a workable forecasting system, production personnel, inventory control personnel, and marketing personnel should cooperate in determining the forecast. This cooperation provides checks and balances for the forecasting procedure. The key inputs of forecasting are information, analysis, experience, and informed judgment. Economic conditions, competitors' actions, consumers' preferences, and other social phenomena often are whimsical. Judgment must be exercised to see that appropriate forecasting methods are developed and properly applied.

Discussion questions

1. “Forecasting of sales is the key to many other types of forecasts.” Explain.
2. “Forecasting is more focused towards science than just being a simple technique.” Judge the above comment.
3. Why is economic forecast important? In developing an economic forecast, what problems can be encountered?
4. In recent times, technological forecasting has been given great emphasis. Why?

Lesson Two: **Different Elements of Forecasting**

Lesson Objective
After completing this lesson you will be able to:

- Identify different steps in forecasting system
- Explain the importance of time horizons in the business forecasting process
- Discuss the forecasting errors

Steps in a Forecasting System
To forecast the demand of an item, you can use the following steps. These steps present a systematic way of initiating, designing, and implementing a forecasting task, through regular updating of data.

- *Determine the uses of the forecast:* At the beginning of a forecasting process, you have to decide what objectives you are trying to obtain or why do you need to forecast?
- *Select the items that are to be forecasted:* After deciding upon the objectives, the next step becomes selecting the products—the goods or services—that have to be forecasted about.
- *Determine the time horizon of the forecast:* The time horizon of the forecast being made is of great importance in ensuring its effectiveness and accuracy of the process. You have to make cautious determination whether it will be short, medium or long term. More discussion on this topic follows shortly.
- *Gather the data needed to make the forecast:* Demand forecast may rely on information of various sorts—historical, causal, environmental, etc. Only relevant data should be considered to ensure the precision of the forecast.
- *Validate the forecasting model:* Among the forecasts prepared using several techniques, you have to calculate their respective errors and compare them. The best approach has to be chosen.
- *Make the forecasts:* Now, you have to set your target production level as per the forecasts of the best model.
- *Implement the result:* Once the demand forecast is final, you produce as per the forecast. Intermittent or periodic checks and feedback are then conducted on the forecast.

Forecasting Time Horizons

The time horizon of forecasting carries much weight in operations management.

You can distinguish among a variety of forecasting activities by considering-how far into the future they focus. While detailed forecasts of specific items are used for short-term operations, overall product demands are forecasted for longer terms to prepare for investment, capacity and layout (Figure 3.2.1). The time horizon of forecasting carries much weight in operations management, as planning and scheduling operations often rely on forecasts of a range of time spans. Forecasting the time horizon can be divided into three specific ranges:

1. *Short range forecast:* A forecast that has a time span of one year but is generally less then three months. The use of such forecast is for purchase

planning, job scheduling, workforce levels, job assignments and production levels.

2. *Medium-range forecast:* Medium range or intermediate range forecast generally spans from three months up to three years. It is useful in sales planning, production planning and budgeting, cash budgeting, and analyzing various operating plans.

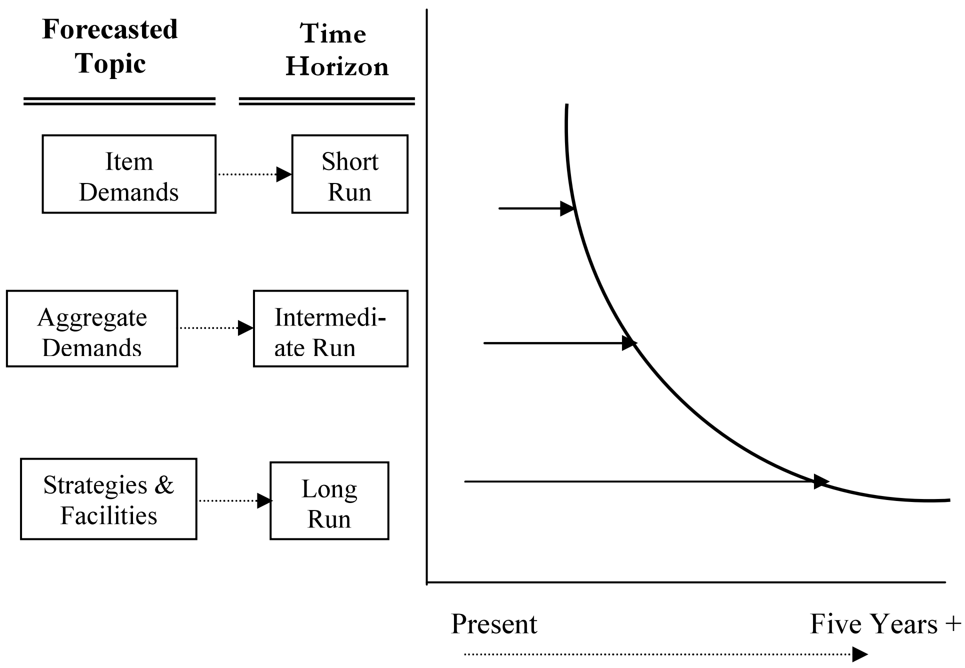

Figure 3.2.1: Decisions involved in various time horizons

3. *Long range forecast:* It is usually used for new products, capital expenditures, facility location or expansion, and research and development.

Features of Short, Medium, and Long Range Forecasts

Medium range and long-range forecasts have three features that distinguishes them from short range forecasts, these are:

> Short-range forecast tends to move more accurate than long-range forecast.

- Short-term forecasting usually employs different methodologies than do long term ones. Mathematical techniques such as moving average, exponential smoothing, trend extrapolations are common to short-range projection.
- Short-range forecast tends to move more accurate than long-range forecast. Factors that influence demand change every day. Thus, as time horizon lengthens, accuracy of forecast will likely to diminish. Therefore sales forecast needs to be updated regularly in order to maintain their value and integrity. After each sales period, the forecast should be reviewed and revised.

- Intermediate and long term forecasts deals with more comprehensive issues and support management decision regarding planning of products, plants and processes.

Activity: Do you think you should use same types of steps for the short to the long range business forecasting? Why or why not? Discuss.

Characteristics of Different Ranges of Forecasts

The comparison of different ranges of forecast with respect to their application, characteristics and forecast techniques is tabulated below (Table 3.2.1).

Table 3.2.1: Comparison of Different Ranges of Forecasts

Ranges of forecasts	Horizon or Time Span	Application	Characteristics	Forecast Method
Long-range	Generally 5 years or more	**Business planning:** • Product planning • Research programming • Capital planning • Plant location & expansion	• Broad, general • Often only qualitative	• Technological • Economic • Demographic • Marketing studies • Judgment
Medium-range	Generally 1 season or 2 years	**Aggregate planning:** • Capital & cash budgets • Sales planning • Production planning • Production & Inventory budgeting	• Numerical • Estimate of reliability needed • Not necessarily at the item level	• Collective opinion • Time series • Regression • Economic index correlation or combination • Judgment
Short-range	Generally less than 1 season or 1 year	**Short-run control:** • Adjustment of production & employment levels • Purchasing • Job scheduling • Project assignment • Overtime decisions	• May be at item level for planning of activity • Should be at adjustment of purchases and inventory	• Trend extrapolation • Graphical • Judgment • Exponential smoothing

Forecasting Errors

The forecast error is the numeric difference of forecasted demand and actual demand.

Forecasting is mainly done to find the near to possible data of the nature of demand or to determine quantity of production based on previous data or hypothesis. For example, if the forecast for the month of November for a product is 326 units, it may be that, in reality the quantity demanded would be less or more then 326 units; the difference of the two is known to be the error, i.e., forecasting error. Therefore the least is the error; the better is the forecast. Forecast not only helps us to determine the demand but also helps us predict how much inventory is to be kept; therefore the excess cost can be minimized.

When an organization evaluates different forecasting methods, the operations managers need a measure of its effectiveness. Forecast error is the scorekeeping mechanism most commonly used. A calculation of average error made by a forecast model over time provides a measure of how well a forecast matches the pattern of past data. This measure is often used as an estimate of how well the model will fit the demand pattern one is trying to predict. Such a measure of alternative forecast models provides a basis for comparison to see which model seems to do the best job. Forecast error is the numeric difference of forecasted demand (F_i) and actual demand (D_i). Obviously organizations never prefer a forecast method yielding large errors. The most commonly used techniques for measuring overall forecast error is *Mean Absolute Deviation* (MAD). This value is computed by taking the sum of the absolute values of the individual forecast errors (F_i - D_i) and dividing by the number of period of data (n).

$$MAD = \frac{\sum_{i=1}^{n} |F_i - D_i|}{n}$$

Here in MAD, we find the difference between the forecasted demand and actual demand. If the forecast is absolutely correct, i.e., the actual demand equals the forecasted demand, the error will be zero. As forecasting continues, the forecast error is recorded and accumulated, period by period. Note that MAD is an average of the forecast errors. Errors are measured without regard to sign, i.e., MAD expresses magnitude, not the direction of errors.

Bias, another measure of forecast error, calculates the forecast error with regard to direction and shows any tendency consistently to over or under forecast. Bias is calculated as the sum of the actual forecast error for all periods divided by the total number of periods calculated. If the forecast repeatedly overestimates actual demand, Bias will have a positive value; consistent underestimation will be indicated by a negative value.

Bias is calculated as the sum of the actual forecast error for all periods divided by the total number of periods calculated.

$$Bias = \frac{\sum_{i=1}^{n} (F_i - D_i)}{n}$$

Assume that, a retail shop owner forecasted the demand for a butter to be 50 units for each of the next three weeks. The actual demand turned out to be 40, 56, and 70 units. His forecast errors, MAD and Bias, are calculated as follows:

MAD = (|50 – 40| + |50 – 56| + |50 – 70|)/3 = 12 units

Bias = [(50 – 40) + (50 – 56) + (50 – 70)]/3 = - 5.3 unit

Summary

To make reliable forecasts, an organization should have a systematic way of initiating, designing, and implementing regular updating of data. Forecast itself is a system comprising of mainly seven steps. At first, organization has to determine the uses or objectives of forecasting. After deciding upon the objectives, the next step becomes selecting the products—the goods or services—that have to be forecasted about. The next steps are determining the time horizon and collecting data. Determining an appropriate forecasting technique or model follows data collection. Then the operations managers have to make the actual forecast based upon the activities taken up so far and implement the result. Intermittent or periodic checks and feedback that are part of result implementation are then conducted on the forecast.

Determining appropriate time horizon is critical for forecasting. The time horizon of forecasting carries much weight in operations management, as planning and scheduling operations often rely on forecasts of a range of time spans. Forecasting the time horizon can be divided into three specific ranges: short-range, medium-range and long-range. Short-range forecasts have a time span of one year but is generally less then three months. The use of such forecasts are for purchase planning, job scheduling, workforce levels, job assignments and production levels. Medium range or intermediate range forecasts generally span from three months up to three years. It is useful in sales planning, production planning and budgeting, cash budgeting, and analyzing various operating plans. Long-range forecasts are usually used for new products, capital expenditures, facility location or expansion, and research and development. When an organization evaluates different forecasting methods, the operations manager needs a measure of its effectiveness. Forecasting error is the scorekeeping mechanism most commonly used. Forecasting error is the numeric difference of forecasted demand and actual demand.

Power Shortage

Case Analysis

In 1964 the National Power Survey by the FPC indicated that electric utility companies of the northeastern section of the U.S. had several excess capacity. The forecasts of the northeastern section of the industry were a declining rate of growth for peak capacity demand. The past 6% growth trend was moving below this level, causing additional over-capacity.

Based in part on this study, the Kilowatt Company adopted a plan that assumed a declining growth pattern. They increased their promotional efforts and reduced some of their rates to encourage electric usage. In addition, they joined a program of pooling generating capacity with other utilities in the region. This would permit switching capacity when demands temporarily created a shortage for one of the member companies. Thus reducing the capital investment requirements.

The actual growth in demand in 1966 exceeded 7%; in 1967 it was about 1.5%; it soared to almost 14% in 1968, and was almost 6% in 1969. As a result, instead of over-capacity, Kilowatt and other utilities in the region found themselves with a severe shortage of generating capacity. This shortage resulted in requests to customers to reduce their use of electric power at certain times. It even led to occasional power blackouts like the famous incident in New York in 1965.

By 1966, Kilowatt found themselves in a position where their peak load capacity was more than 60,000 kilowatts less than the forecast peak load. Because of the slower increase in demand and an increase in capacity, in 1967 the forecast exceeded actual demand by more that 100,000 kilowatts. However, in 1968 and 1969, the forecast was more than 200,000 kilowatts below actual.

Case questions

1. How could such a wide disparity between forecasted usage and actual usage occur in view of the forecasting techniques available?
2. What factors could affect peak load growth?
3. What factors might have contributed to a greater growth rate than forecasted?
4. What can Kilowatt do to overcome their present difficulties and what should they do to avoid such large forecasting errors in the future?

Discussion questions

1. How do some investments in forecasting results in a negative return?
2. How accurate should the government forecast need to be and why? Explain with the help of two such situations.
3. Is there any difference between forecasting demand and forecasting sales?
4. Explain how an organization can become confused when the distinction between forecasting and planning is not clear.

Lesson Three: Different Forecasting Approaches/Techniques

Lesson Objective

After completing this lesson you will be able to:

- Explain different qualitative forecasting techniques
- Identify different quantitative forecasting techniques.

Different Forecasting Approaches

Forecasts can range from instantaneous hunches to elaborate statistical equations. There is no way to be sure that a specific technique is best for a specific situation. Some are simple and more common, while some complex ones may be more accurate. Broadly, there are two general approaches to forecasting dominant in operations management. These are,

There is no specific & best technique of forecasting for a specific situation.

i) The qualitative approach and
ii) The quantitative approach

Subjective or qualitative intuitive forecast incorporates factors such as the decision-maker's guesses, hunches, intuition, emotion and personal experiences, and value system in reaching a forecast. *Quantitative forecast* employs a variety of mathematical models that use historical data or casual variables to forecast demand. Some firms use one approach, while some use the other. In practice a combination or blending of the two styles is usually most effective. Within the quantitative approach are two basic types of models, which are distinguished, by the type of the data they use. The *demand-based* models mainly rely on historical data about the item that is being forecasted. The *causal models*, on the other hand, might formally relate the demand to other variables believed to influence the demand. The Figure 3.3.1 shows the different forecasting methods, which is detailed in the following sections.

A combination or blending of the two styles is usually most effective.

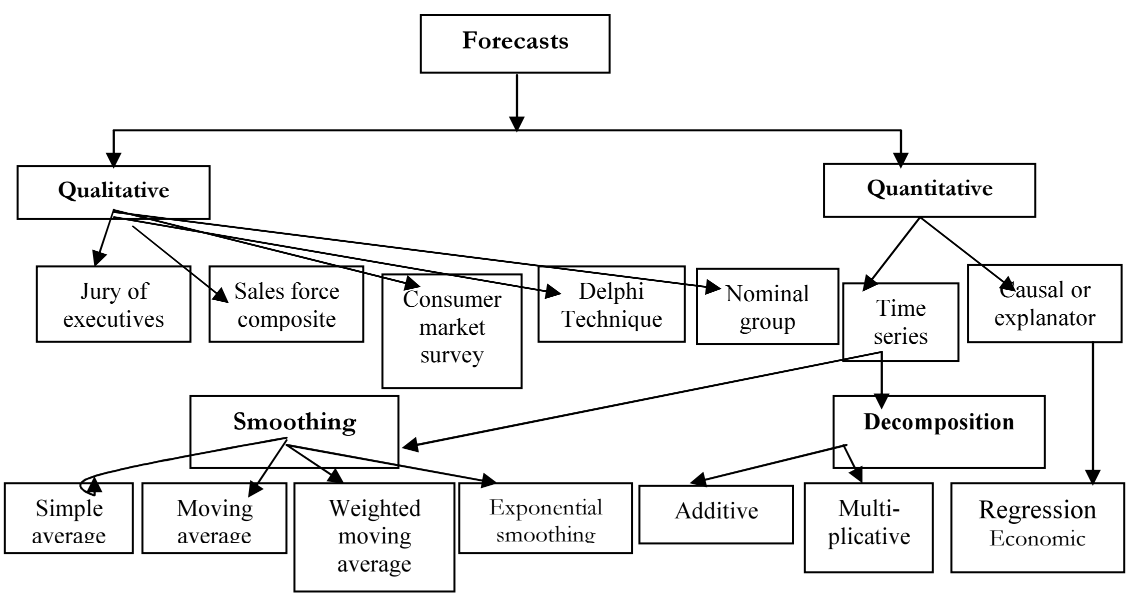

Figure 3.3.1: Different forecast methods

The Qualitative Methods of Forecasting

1) **Jury of executive opinion:** Under this method, the opinions of a group of high-level managers often in combination with statistical models, are pooled to arrive at a group estimate of demand.

2) **Sales force composite:** In this approach each sales person estimates what sales will be in his/her region. This forecast are then reviewed to ensure they are realistic and then combined at the district and national levels to reach an over all forecast.

3) **Consumer market survey:** This method solicits input from customers or potential customers, regarding their future purchasing plans. It can help not only in preparing a forecast, but also in improving product design and planning for new products.

Delphi method is a group process intended to achieve a consensus forecast avoiding direct inter-personal relations.

4) **Delphi method:** This is a group process intended to achieve a consensus forecast. There are three different types of participants in the Delphi method– (1) decision-makers/experts, (2) staff personal/coordinator and (3) respondents. The key to the Delphi technique lies in the coordinator and experts. The decision makers usually consist of a group of five to ten experts who will be making actual forecasts, the staff personal or coordinator assists the decision makers by preparing, distributing, collecting and summarizing a series of questionnaires and survey results. The respondents are a group of people often located in different places, whose judgments are valued and are being sought. This group provides inputs to the decision-makers before the forecast is made. The procedure works as follows:
    a. A coordinator poses a question, in writing, to each expert of a panel.
    b. Each expert writes a brief prediction.
    c. The coordinator brings the written predictions together, edits them, and summarizes them.
    d. On the basis of the summary, the coordinator writes a new set of questions and gives them to the experts. These are answered in writing.
    e. Again, the coordinator edits and summarizes the answers, repeating the process until the coordinator is satisfied with the overall prediction synthesized from the experts.

   An advantage of this method is that direct interpersonal relations are avoided. Hence personalities do not conflict, nor one strong-willed member dominates the group. On the other hand, Delphi technique is time consuming.

The nominal group technique affords opportunity for discussion among the experts.

5) **Nominal group discussion technique:** Like Delphi technique, the nominal group discussion involves a panel of experts. Unlike the Delphi technique, the nominal group technique affords opportunity for discussion among the experts. Here seven to ten experts are asked to sit around a table in full view of one another, but they are asked not to communicate with one another. A group facilitator hands out copies of the question needing a forecast. Each expert is asked to write down a list of ideas about the question. After a few minutes, the group facilitator asks each expert in turn to share one idea from his or her list. A recorder writes each idea on a flip chart so that everyone can see it. The experts continue to give their ideas (usually between 15-25) in a round-robin manner until all the ideas have been written on the flipchart. No discussion takes place in this phase of the meeting.

During the next phase of the meeting, the experts discuss all the ideas that have been presented. Often similar ideas are combined. When all discussion has ended, the experts are asked to rank the ideas, in writing, according to priority. The consensus is the mathematically derived outcome of the individually rankings. The advantage of the nominal group discussion is time saving. But this technique can fail if the coordinator fails to allow creativity and encourage discussion. There is also the risk of getting all the experts together. This also can become costly if the experts are to be brought from foreign countries.

The advantage of the nominal group discussion is time saving.

Activity: Think about the process of 'new product design' of your firm. In this case what qualitative methods of forecasting you will chose? Why? Discuss.

Quantitative Method of Forecasting

Naïve (Time Series) Quantitative Models: The time series model predicts the simple assumption that the future is a function of the past. In other words, they look at what has happened over a period of time and use a series of past data for forecasting. Some of the tools are:

a) Simple average
b) Moving average
c) Exponential smoothing

(a) Simple Average

Simple average ($\overline{X}$) is the simplest way to forecast assuming that the demand in the next period will equal to the average of the past demands. Here the demands of the previous periods are equally weighted.

$$\overline{X} = \frac{\text{sum of demands for all periods}}{\text{number of periods}} = \frac{\sum_{i=1}^{n} Di}{n}$$

Where,

D_i = the demand in the 'i'th period
n = number of periods

By averaging, we try to detect the pattern or central tendency of demand. The demand for any one period will probably be above or below the underlying pattern, and demands for several periods will be dispersed or scattered around the pattern. Therefore, if we average all past data the extreme values will be offset and the result will be an average that is representative of the period by reducing the chances of being misled by gross fluctuations that may occur in any single period. But we have to be careful about the fact that, if the underlying pattern changes over time simple averaging will not detect this change.

Example (i)

If a mobile communication company sales 100, 110, and 96 mobile connection in the month of January, February and March respectively, we can assume that the demand for April will be 102 [(100+110+96)/3]. This may not be exact but for a starter it could be on the best-cost effective solution for some organization. In many cases we give different weights to the past data, especially giving more weight to the most recent data, making it simple weighted average.

$$\overline{X} = \frac{sum\ of\ demands\ \ for\ all\ \ periods}{number\ \ of\ \ periods} = \frac{\sum_{i=1}^{n} WiDi}{\sum Wi}$$

Where,

D_i = the demand in the 'i'th period
W_i = the weights of the 'i'th period

Example (ii)
In the above forecast example if weights of 20%, 30% and 50% are given for the demand figures of January, February and March respectively, then the demand forecast for April will be 101 [(100x0.20 + 110x0.30 + 96x0.50)/1.00].

Moving average is useful if we can assume that market demands will stay fairly steady over a period of time.

(b) Moving average
A moving average forecast uses a number of recent actual data values from several of the most recent periods to generate a forecast. Once the number of past periods to be used in the calculations has been selected, it is held constant. Moving average is useful if we can assume that market demands will stay fairly steady over a period of time. A 4-month moving average is found by simply summing the past 4-month data and divided by 4 and so on. The average "moves" over time, in that, after each period elapses, the demand for the oldest period is discarded and the demand for the newest period is added for the next calculation. This overcomes the major shortcoming of the simple averaging model. Moving average can be of two types:

i) Simple moving average, where demands of all periods are equally weighted.
ii) Weighted moving average, which allows varying, not equal, weighting of the old demands.

A simple moving average (SMA) is calculated as follows:

$$SMA = \frac{sum\,of\,demands\ for\ periods}{chosen\,number\,of\ \ periods} = \frac{\sum_{i=1}^{n} Di}{n}$$

Where,

D_i = the demand in the 'i'th period
n = chosen number of periods
i = 1 is the oldest period in the n-period average
= n is the most recent period

Example: (i)

Month	Actual Sales	3-month moving average forecast
January	120	
February	130	
March	110	
April	150	(120+130+110)/3 = 120
May	-	(130+110+150)/3 = 130

When there is a detectable trend or pattern, weights can be used to place more emphasis on recent values. This makes the technique more responsive to changes because more recent periods may be more heavily weighted. Selection of weights requires experience and luck, because there is no set formula to do so. The Weighted Moving Average (WMA) is calculated by using the following model:

$$WMA = \sum_{t=1}^{n} C_t D_t$$

Where,

n = chosen number of periods
t = 1 is the oldest period in the n-period average
= n is the most recent period
D_i = the demand in the 'i'th period
C_t = Weight against a particular periodic demand $0 \le C_t \le 1$
$\sum C_t = 1$

Example (ii)
In the previous example if we weight most recent period twice as heavy as other two periods by setting, $C_1 = 0.25$, $C_2 = 0.25$, $C_3 = 0.50$, the demand forecast for the month of May will be; WMA = 0.25 x 130 + 0.25 x 110 + 0.50 x 150 = 135

(c)Exponential smoothing
Exponential smoothing is a sophisticated weighted moving average forecasting method that is still fairly easy to use. It involves very little record keeping of past data. Exponential smoothing is distinguishable by the special way it weights each past demand. The pattern of weights is exponential in form. Demand for the most recent period is weighted most heavily; the weights placed on successively older periods decrease exponentially. The basic exponential smoothing formula for creating a new or updated forecast (F_t) uses two pieces of information:

(i) actual demand for the most recent period (D_{t-1})

(ii) most recent demand forecast (F_{t-1})

As each time period expires, a new forecast is made using:

$$F_t = \alpha D_{t-1} + (1 - \alpha) F_{t-1}$$

Where,

F = Forecast
α = smoothing coefficient ($0 \le \alpha \le 1$)
D = demand
t = is the period
t – 1 = immediate previous period.

- **Why is the Model called Exponential Smoothing?**
  Since,

$F_t = \alpha D_{t-1} + (1- \alpha) F_{t-1}$ (1)

Then,

$F_{t-1} = \alpha D_{t-2} + (1- \alpha) F_{t-2}$ (2)

Similarly,

$F_{t-2} = \alpha D_{t-3} + (1- \alpha) F_{t-3}$ (3) and so on ….

If we replace F_{t-1} in equation (1) by its equivalent value from equation (2), we get,

$$F_t = \alpha D_{t-1} + (1-\alpha)[\alpha D_{t-2} + (1-\alpha) F_{t-2}]$$
$$= \alpha D_{t-1} + \alpha(1-\alpha) D_{t-2} + (1-\alpha)^2 F_{t-2} \quad (4)$$

If we continue expanding by replacing F_{t-2} in equation (4) by its equivalent from equation (3), we get,

$$F_t = \alpha D_{t-1} + \alpha(1-\alpha) D_{t-2} + \alpha(1-\alpha)^2 D_{t-3} + (1-\alpha)^3 F_{t-3}$$
$$= \alpha(1-\alpha)^0 D_{t-1} + \alpha(1-\alpha)^1 D_{t-2} + \alpha(1-\alpha)^2 D_{t-3} + (1-\alpha)^3 F_{t-3}$$

The above model self-explains why it is called exponential smoothing (please note in each of the terms the exponents are increasing).

- **Smoothing Coefficient Selection**

The selection of smoothing coefficient (α) is very important for effective use of the exponential smoothing model. We have to be careful while taking the value of α. A high value of α places heavy weight on the most recent demand and a low α value weights recent demand less heavily. For example, when $\alpha = 0.8$, the model becomes,

$$F_t = \alpha(1-\alpha)^0 D_{t-1} + \alpha(1-\alpha)^1 D_{t-2} + \alpha(1-\alpha)^2 D_{t-3} + (1-\alpha)^3 F_{t-3}$$
$$= 0.80\, D_{t-1} + 0.16\, D_{t-2} + 0.032\, D_{t-3} + \ldots$$

On the other hand, when $\alpha = 0.2$, the model becomes,

$$F_t = \alpha(1-\alpha)^0 D_{t-1} + \alpha(1-\alpha)^1 D_{t-2} + \alpha(1-\alpha)^2 D_{t-3} + (1-\alpha)^3 F_{t-3}$$
$$= 0.20\, D_{t-1} + 0.16\, D_{t-2} + 0.128\, D_{t-3} + \ldots\ldots$$

Hence, for a new product or for items with a dynamic or unstable demand, a higher value of α (0.7 to 0.9) is more justifiable. In case of a product that is in the market for a longer period of time and the demand of the product is of less variance, the value of α is to be taken from the range of 0.1 to 0.3, to smooth out any sudden noise[2] that might have occurred. When demand is slightly unstable, smoothing coefficient of 0.4, 0.5, 0.6 might provide most accurate forecasts.

Example (i)

Say there is a new product, and the forecast for the month of November has to be calculated considering that the demand of the product in September is 300 and in October is 350. The forecast for September was 200 units. As the product is new, the value of α is to be taken from the range of 0.7 to 0.9. In this case let the value be 0.7:

[2] Noise is any dispersion or deviation of demand from the actual demand pattern.

Therefore,

$F_{October} = \alpha D_{September} + (1-\alpha) F_{September}$

$= 0.7 \times 300 + (1-0.7)\ 200$

$= 270$

$F_{November} = \alpha D_{October} + (1-\alpha) F_{October}$

$= 0.7 \times 350 + (1-0.7)\ 270$

$= 326$

Therefore the forecast for the month of November = 326.

Summary

There are different forecasting approaches that range from instantaneous hunches to elaborate statistical equations. Some are simple and more common, while some complex ones may be more accurate. Broadly, two types of general approaches to forecasting dominates operations management. They are the qualitative approach and the quantitative approach. The Qualitative Methods include jury of executive opinion, sales force, composite consumer market survey, Delphi method and nominal group discussion technique, etc. Among these techniques, Delphi method and nominal group discussion are most used. An advantage of this method is that direct interpersonal relations are avoided. On the other hand, Delphi technique is time consuming. Like Delphi technique, the nominal group discussion involves a panel of experts. Unlike the Delphi technique, the nominal group technique affords opportunity for discussion among the experts. The advantage of the nominal group discussion is time saving. But this technique can fail if the coordinator fails to allow creativity and encourage discussion. Quantitative Methods include Naïve (time series) quantitative models that in turn include simple average, moving average, exponential smoothing etc. The time series model predicts the simple assumption that the future is a function of the past. In other words, they look at what has happened over a period of time and use a series of past data for forecasting.

Brother's Packing Box Company

Case Analysis

Brother's Packing Box Company is a small, closely held private corporation operating for 8 years and located in Chittagong EPZ, Bangladesh. The stock of the company is divided among three brothers. The principal shareholder is the founding brother, Abdul Mannan Khan, who had worked for a similar company for 20 years in England.

Brother's Packing Box Company supplies corrugated (folded) cartons to many RMG factories situated in the EPZ area. Abdul Mannan Khan attributes his success to the fact that he has been able to capture the EPZ market by supplying boxes to many small firms as well as the big companies. Abdul Mannan Khan has enforced the policy that no single customer can account for over 20 percent of sales as he recognizes the danger of becoming too dependent on one client. Two of his biggest clients account for 20 percent of sales each, and hence are limited in their purchases. A.M Khan has convinced the purchasing agents of these two companies to add other suppliers. This alternative supply protects Brothers might have in paper shortage etc.

Brother's Packing Box Company has currently over 250 customers with orders ranging from a low of 100 boxes to set orders for 5,000 folded packing boxes per year. Boxes are produced in 16 standard sizes with special printing to customer's specifications. Brother's printing equipment limits their print to two colors. The standardization and limiting printing allows Brother's to be price competitive with other box manufacturers. But they can also provide the service for small and "emergency" orders.

Such personal service, however, requires tight inventory control and close production scheduling. So far, A.M. Khan has always forecast demand and prepared production schedules through experience. But because of the ever-growing number of accounts and changes in personnel in customer purchasing departments, the accuracy of his forecasting has been rapidly declining. The inventory levels of finished boxes along with number of back orders are on the increase.

Later orders are more common. A second warehouse has recently been leased due to the overcrowded conditions in the main warehouse. Plans are to move some of the slower moving boxes to the leased space. There has always been an increase in demand for boxes prior to the winter season when more and more orders of knit and woven garments are shipped out to many countries. Such seasonality in demand has always substantially increased the difficulty of making a reliable forecast.

Mr. A. M. Khan feels that it is now important to develop an improved forecasting method. It should take both customer growth and seasonality into consideration. He believes that if such a method can be applied to forecasting total demand, it can also be used to forecast demand for the larger customers. The requirements of the smaller customers could then be integrated to smooth production and warehousing volume.

Mr. A. M. Khan has complied the following demand data.

Sales (in hundreds of boxes)					
Month	1996	1997	1998	1999	2000
January	12	8	12	15	15
February	8	14	8	12	22
March	10	18	18	14	18
April	18	15	13	18	18
May	14	16	14	15	16
June	10	18	1	18	20
July	16	14	817	20	28
August	18	28	20	22	28
September	20	22	25	26	20
October	27	27	28	28	30
November	24	26	18	20	22
December	18	10	18	22	28
	195	216	209	230	265

Case questions

1. Develop a forecasting method for Brother's and forecast total demand for 2001.
2. How might Mr. A. M. Khan improve the accuracy of the forecast?
3. Should Mr. Khan's experience with the market be factored into the forecast? If so, how?

Discussion questions

1. Forecasting methods need to be monitored and controlled properly—why?
2. How does correlation play a key role in forecasting?
3. How can a manager evaluate the reliability and the level of confidence of a forecast?
4. In what situation you might use quantitative forecasting method though having historical data?

Lesson Four: Time Series Decomposition

Lesson Objectives

After completing this lesson you will be able to:

- Understand the different components of Time Series
- Explain the general forms of Time Series Decomposition model
- Analysis the casual quantitative model

Analyzing time series means breaking down past data into components and then projecting them forward.

To systematically analyze historical data for forecasting, we commonly use a time series analysis. Here we plot demand data on a time scale, study the movements, and look for consistent shapes or patterns. A time series demand might have a variety of components. Analyzing time series means breaking down past data into components and then projecting them forward. A time series typically has four components: trend, seasonality, cycle and random variation. *The Trend component* is the general upward or downward movement of the average level of demand over time. Consider the Figure 3.4.1 which shows the example of the trend component.

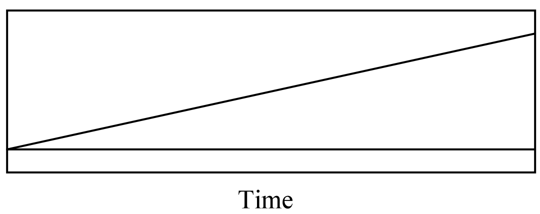

Figure 3.4.1: The Trend Components

The Seasonal component is the recurring fluctuations of demand above and below the trend value that repeats with a fairly consistent interval. Seasonal pattern can repeat itself after a period of time, which can be in the form of days, weeks, months or quarters or with some other interval. A classification of the seasonal component appears in the Figure 3.4.2.

Period of pattern	Season of length	No. of season in pattern
Week	Day	7
Month	Week	4 – 41/3
Month	Day	28-31
Year	Quarter	4
Year	Month	12
Year	Week	52

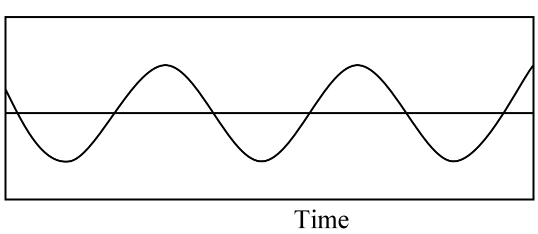

Figure 3.4.2: The seasonal components

The Cyclical component as shown in Figure 3.4.3, is the recurring upward or downward movement that repeats with a frequency that is longer than 1 year. As many as 15 or 20 years of data may be required to determine and describe the cyclical component. Cycles are pattern in the data that occur every several years, they are tied into the business cycle and are of major importance in short term business analyses planning.

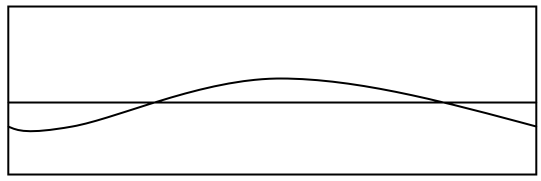

Figure 3.4.3: The Cyclical Components

The Random component depicted in Figure 3.4.4, is the series of short, erratic movements that follow no discernible pattern.

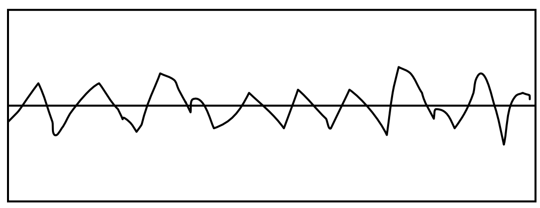

Figure 3.4.4: The Random Components

The pattern is the general shape of the time series. Although some individual data points do not fall on the pattern, they all tend to cluster around it. To describe the points clustered about a pattern, we use the term *noise*. Low noise means all or most of the points lie very close to the pattern. High noise means many of the points lie relatively far away from the pattern. When random component of a time series has fluctuations that deviate substantially from the average level of demand, it is often useful to smooth out the data by averaging several observations to make the basic pattern more apparent which is known as Time Series Smoothing.

Time Series Decomposition model

When a seasonal variation is evident in the demand pattern and the effect of seasonality is to be included in the forecast it is commonly used as Time Series Decomposition. Therefore, the Time Series Decomposition is separation of the overall series into some of its basic components that are more likely to have recognizable and more predictable patterns. These basic components can then be projected into the future and recombined to form a forecast. The four basic components of time series as we have noted are Trend, Cyclical, Seasonal, and Random. The decomposition approach is based on the assumption that these components act independently of one another. If they are projected into the future, it is assumed that the forces that have caused them to occur in the past will continue.

The Time Series Decomposition model is separation of the overall series into some of its basic components that are more likely to have recognizable and more predictable patterns.

General forms of time series decomposition models
Time series has two common models: these are, (1) Multiplicative model and (2) Additive model.

(1) **Multiplicative model**: The most common model is the ***Multiplicative model***, in which forecast is done by multiplying all the time series components.

$$TF= T \times S \times C \times R$$

(2) **Additive model**: In the other model in the time series i.e. the ***Additive model***, forecast is done through adding the time series components.

$$TF= T + S + C + R$$

Here,

TF = time series forecast
T= trend component
S= measure of seasonality, either a ratio or an amount to add
C= measure of cyclical adjustment, either a ratio or an amount to add
R= random component

Visual inspection of a plotted time series is often helpful to determine the type of model that most appropriately represents the data (Figure 3.4.5).

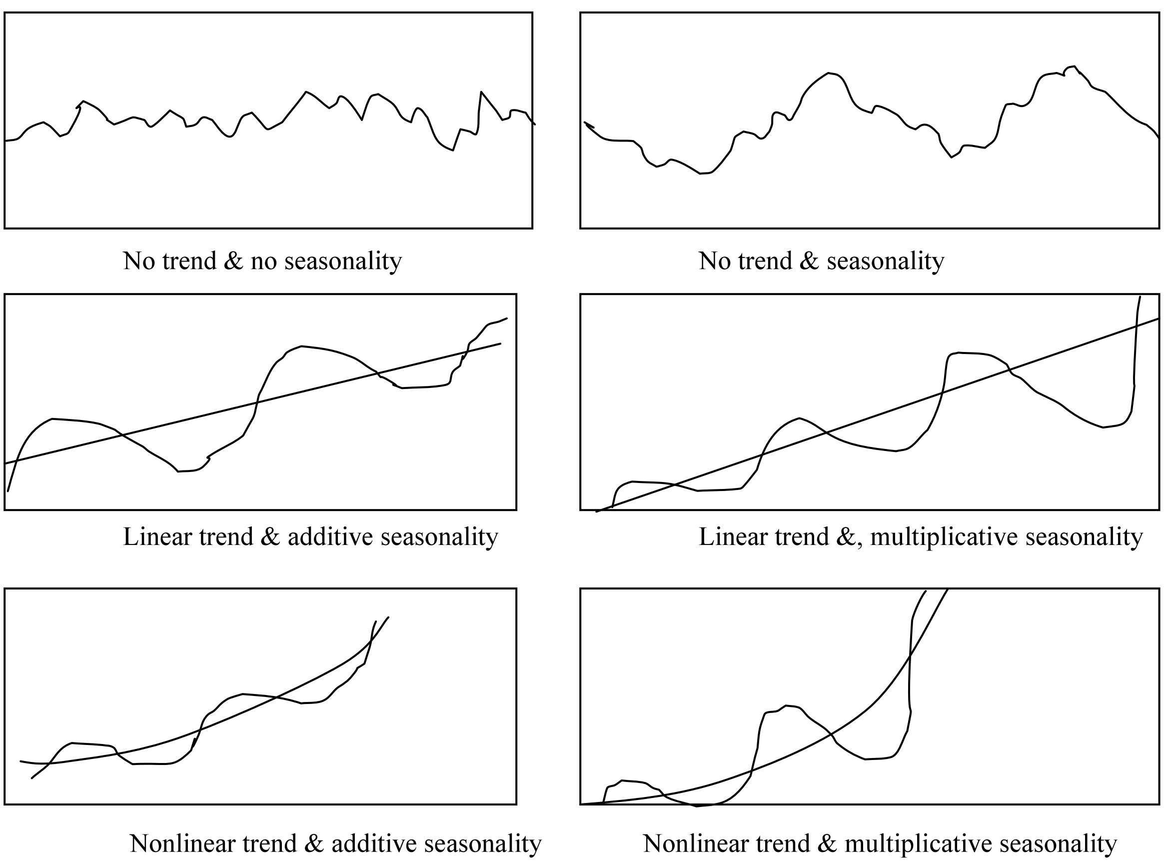

Figure 3.4.5: Different linear and non-linear additive and multiplicative seasonality

Defining and separating trend and cycle components may necessitate considering data for a period of 15 to 20 years, which (data) might not be available. Moreover, very few products remain in stable condition this long—either due to competitive situation or due to change in product life cycle stage. Hence, it is not unusual to estimate trend from considering data of 2 years or more as available. The random component is assumed to be averaged out over the multiple observations. Consequently, in practice only the seasonal component and the combination of trend-cycle component is considered. The following example of time series decomposition will help you to calculate the trend component and the seasonal coefficient.

Example: The Table 3.4.1 pertains to the quarterly sales data of 1- liter-pack milk of Shelaidah Dairy Ltd. For 1999 and 1998. The data has been further calculated to facilitate the time series decomposition. In this example the cyclical component is not considered, as we did not have enough data for the purpose. The random component is smoothed out as we took the quarterly sales. Only trend and seasonal component is taken into account. The 4-quarter moving average shows an upward trend in the sales.

Table 3.4.1 Quarterly sales data shelaidah dairy ltd.

Year	Quarter	Quarter number	Sales (units)	4-quareter moving average
1998	First quarter (Jan—Mar)	1	4744	-
	Second quarter (Apr—Jun)	2	1517	-
	Third quarter (Jul—Sep)	3	1526	-
	Fourth quarter (Oct—Dec)	4	2243	2507.50
1999	First quarter (Jan—Mar)	5	5074	2590.00
	Second quarter (Apr—Jun)	6	1397	2560.00
	Third quarter (Jul—Sep)	7	1948	2665.50
	Fourth quarter (Oct—Dec)	8	5375	3448.50

From the above figure we will calculate the trend value and the seasonal coefficient.

- **Calculation of trend component**

The lowest point of the trend line (at the beginning of quarter # 1) shows sales of 2600 units (appx.) and the highest point (at the end of quarter # 8) shows sales of 3400 units (appx.).

Trend component = (3400—2600) / 8 = 100

Here, the divisor 8 is the number of quarters considered for calculating the trend line.

- **Calculation of seasonal coefficient**

Dividing the actual sales by the sales value on the trend line and averaging the corresponding quarters will give the corresponding seasonal coefficient. If the actual sales and sales value of the trend line is close to each other a seasonal coefficient of 1.00 can be taken.

Quarters	Year 1	Year 2	Seasonal coefficient (S)
First quarter	(4744/2600)=1.82	(5074/3050)=1.66	(1.82+1.66)/2=1.74
Second quarter	(1517/2700)=0.56	(1397/3150)=0.44	(0.56+0.44)/2=0.50
Third quarter	(1526/2850)=0.54	(1948/3300)=0.59	(0.54+0.59)/2=0.565
Fourth quarter	(2243/2950)=0.76	(5375/3400)=1.58	(0.76+1.58)/2=1.17

Calculation of trend value:

Trend value = 2600 + Trend component * (Number of quarter)
= 2600 + 100 * (Number of quarter)

Forecasting for different quarters:

Quarter (Year 2000)	Quarter Number	Trend Value (T)	Seasonal Index (S)	Forecast (T * S)
First quarter	9	2600 + 100 * (9)=3500	1.74	6090
Second quarter	10	2600 + 100 * (10)=3600	0.50	1800
Third quarter	11	2600 + 100 * (11)=3700	0.565	2090
Fourth quarter	12	2600 + 100 * (12)=3800	1.17	4446

Casual Quantitative Model: Casual model, as noted, incorporates dependency of the variables or factors that might influence the quantity being forecast.

Regression model

Regression model is a causal forecasting technique output that establishes a relationship between variables. There is one dependent variable and one or more explanatory variables. Historical data establishes a functional relationship between the two variables. If there is one explanatory variable it is called simple regression, otherwise, it becomes multiple regression. If the model takes the shape of a linear equation, we call it simple linear regression or multiple linear regression models. Normally least square curve fitting technique is used to develop the models for fitting a line to a set of points.

Simple Linear Regression

The simplest and most widely used form of regression involves a linear relationship between two variables. A plot of the values might appear like that in Figure 3.4.6.

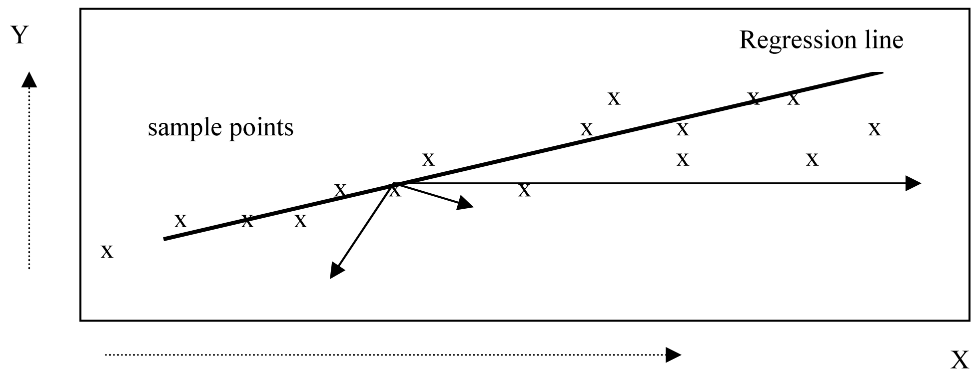

Figure 3.4.6: A straight line fitted to a set of sample points

The objective in linear regression is to obtain an equation of a straight line that minimizes the sum of squared vertical deviations of data points from the line. This least square curve has the equation:

$$Y = a + bX$$

Where,

- Y → predicted (dependent) variable [normally drawn on the Y-axis]
- X → explanatory (independent) variable [normally drawn on the X-axis]
- a → value of predicted variable (Y) when x = 0 (Y-intercept value of the line)
- b → slope of the line (change in Y corresponding to a unit change in X)

The coefficients a and b of the regression line are computed using the following two equations:

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

$$where, n \rightarrow number\ of\ paired\ observations$$

$$a = \frac{\sum y - b\sum x}{n} = \bar{y} - b\bar{x}$$

$$where, \bar{y} \rightarrow mean\ of\ x\ vlues\ \&\ \bar{x} \rightarrow mean\ of\ y\ values$$

Example

XYZ Fashions has a chain of twelve stores in Dhaka. Sales figure and profits for the stores are shown in the following table. (Figures are in ‘000taka).

Sales (X)	Profits (Y)	Sales (X)	Profits (Y)
70	1.5	120	2.0
20	1.0	140	2.7
60	1.3	200	4.4
40	1.5	150	3.4
140	2.5	70	1.7
150	2.7		
160	2.4		

a) Does a linear model seem reasonable?
b) Develop a regression model for the data and predict profit for a store assuming sales of Tk. 100,000.

Solution

a) If we plot the points (Figure 3.4.7) we can see that the points seem to scatter around a straight line. Hence, we can conclude that a linear model seems reasonable.

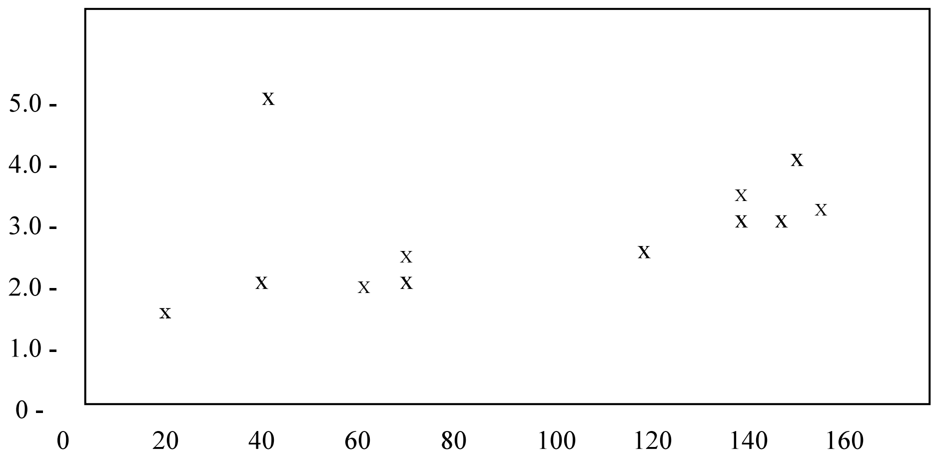

Figure 3.4.7: Scatter Diagram for the Sales & Profits Figures of XYZ Fashions

b) Now for developing the regression model let's compute the quantities Σx, Σy, Σxy, and Σx^2.

x	y	xy	x^2
70	1.5	105	4,900
20	1.0	20	400
60	1.3	78	3,600
40	1.5	60	1,600
140	2.5	350	19,600
150	2.7	405	22,500
160	2.4	384	25,600
120	2.0	240	14,400
140	2.7	378	19,600
200	4.4	880	40,000
150	3.4	510	22,500
70	1.7	119	4,900
Σx =1320	Σy = 27.1	Σxy = 3529	Σx^2 = 179,600

Substituting into equations, we find:

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} = \frac{12(3529) - 1320(27.1)}{12(179{,}600) - 1320^2} = 0.01593$$

Thus the regression equation is: Y = 0.506 + 0.01593X

It is important to note that the regression line should only be used for the range of values from which it was developed; the relationship may be non-linear outside the range.

$$a = \frac{\sum y - b\sum x}{n} = \bar{y} - b\,\bar{x} = 2.26 - 0.01593\,x\,110 = 0.506$$

$$where,\ \bar{y} \rightarrow mean\ of\ x\ vlues\ \&\ \bar{x} \rightarrow mean\ of\ y\ values$$

Trend Equation

A linear trend equation has the form:

$Y_t = a + bt$

where,

t = specified number of time period from t=0

Y_t = forecast for period t

a = value of Y_t at t=0

b = slope of the line.

This equation is identical to the linear regression line, except that t replaces x in the equation. Hence,

$$b = \frac{n(\sum ty) - (\sum t)(\sum y)}{n(\sum t^2) - (\sum t)^2}$$

$$where,\ n \rightarrow Number\ of\ periods,\ y \rightarrow Value\ of\ the\ time\ series$$

Example

Consider the trend equation, $Y_t = 45 + 5t$. Here the value of Y_t when t = 0 is 45, and the slope of the line is 5. The slope indicates that, on the average, the value of Y_t will increase by 5 units for each one-unit increase in t.

$$a = \frac{\sum y - b\sum t}{n} = \bar{y} - b\,\bar{t}$$

$$where,\ \bar{y} \rightarrow mean\ of\ y\ values\ \&\ \bar{t} \rightarrow mean\ of\ t\ values$$

Summary
A summary of advantages and disadvantages of the prominent forecasting techniques for comparison shows the following table.

Model Name	*Advantages*	*Disadvantages*
Qualitative Approach		
Jury of Executive Opinion	• Quick and simple to use • Brings in a variety of viewpoints	• Subject to biases of opinion and judgement • Unsupported by data
Sales force composite technique	• Salespeople's intimate market knowledge is utilized • Participation in forecasting motivates sales-force	• Salesmen may understate or overstate the forecast to make it favorable
Delphi Technique	• Brings in various viewpoints • Interpersonal relations are avoided • Personality conflict and domination by any member is avoided	• No scope for interaction • Time consuming • Ultimately the coordinator takes the decision
Nominal Group Discussion	• No biases or influences • Brings in different opinions • Takes less time • There is interaction among participants	• More expensive, like cost of accommodation • Technique can fail if the coordinator fails to allow creativity and encourage discussion • Chances for biases
Naïve (time series) Quantitative Models		
Simple average	• Extreme values are offset • Gross fluctuations are avoided	• Cannot be used for seasonal and unstable products • Cannot detect changes of patterns over time
Moving average	• Most recent data are considered	• Data of too many periods may make it less responsive to changes in demand pattern
Exponential Smoothing	• Needs very little record keeping	• Inexperienced smoothing coefficient (α) selection may lead to inaccurate forecast
Casual Quantitative Models		
Regression Analysis	• Usually useful for long term trend analysis	• The process is Complex and cumbersome • Requires much data