UNIT 17 BUSINESS FORECASTING

Objectives

After completion of this unit, you should be able to :

- realise that forecasting is a scientific discipline unlike ad hoc predictions
- appreciate that forecasting is essential for a variety of planning decisions
- become aware of forecasting methods for long, medium and short term decisions
- use Moving Averages and Exponential smoothing for demand forecasting
- understand the concept of forecast control
- use the moving range chart to monitor a forecasting system.

Structure

17.1 Introduction

17.2 Forecasting for Long Term Decisions

17.3 Forecasting for Medium and Short Term Decisions

17.4 Forecast Control

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17.6 Self-assessment Exercises

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17.1 INTRODUCTION

Data on demands of the market may be needed for a number of purposes to assist an organisation in its long term, medium and short term decisions. Forecasting is essential for a number of planning decisions and often provides a valuable input on which future operations of the business enterprise depend. Some of the areas where forecasts of future product demand would be useful are indicated below :

i) Specification of production targets as functions of time.
ii) Planning equipment and manpower usage, as well as additional procurement.
iii) Budget allocation depending on the level of production and sales.
iv) Determination of the best inventory policy.
v) Decisions on expansion and major changes in production processes and methods.
vi) Future trends of product development, diversification, scrapping etc.
vii) Design of suitable pricing policy.
viii) Planning the methods of distribution and sales promotion.

It is thus clear that the forecast of demand of a product serves as a vital input for a number of important decisions and it is, therefore, necessary, to adopt a systematic and rational methodology for generating reliable forecasts.

The Uncertain Future

The future is inherently uncertain and since time immemorial man has made attempts to unravel the mystery of the future. In the past it was the crystal gazer or a person allegedly in possession of some supernatural powers who would make predications about the things-to be-major events or the rise and fall of kings. In today's world, predictions are being made daily in the realm of business, industry and politics. Since the operation of any capital enterprise has a large lead time (1-5 years is typical), it is clear that a factory conceived today is for some future demand and the whole operation is dependent on the actual demand coming up to the level projected much earlier. During this period many circumstances, which might not even have been imagined, could come up. For instance, there could be development of other industries, or a major technological breakthrough that may render the originally conceived product obsolete; or a social upheaval and change-of government may redefine priorities of growth and development; or an unusual weather condition like drought or floods may alter completely the buying potential of the originally conceived market. This is only a partial list to suggest how uncertainties from a variety of sources can enter to make the task of prediction of the future extremely difficult.

It is proper at this stage to emphasise the distinction between **prediction** and **forecasting**. Forecasting generally refers to the scientific methodology that often uses past data along with some well-defined assumptions or `model' to come up with a `forecast' of future demand. In that sense, forecasting is objective. A prediction is a subjective estimate made by an individual by using his intuitive `hunch' which may in fact come out true. But the fact that it is subjective (A's prediction may be different from B's and C's) and non-realisable as a Well-documented computer programme (which could be used by anyone) deprives it of much value. This is not to discount. the role of intuition or subjectivity in practical decision-making. In fact, for complex long term decisions, intuitive methods such as the Delphi technique are most popular. The opinion of a well informed, educated person is likely to be reliable, reflecting the well-considered contribution of a host of complex factors in a relationship that may be difficult to explicitly quantify. Often forecasts are modified based on subjective judgment and experience to obtain predictions used in planning and decision making.

The future is inherently uncertain and any forecast at best is an educated guess with no guarantee of coming true. In certain purely deterministic systems (as for example in classical physics the laws governing the motion of celestial bodies are fairly well developed) an unequivocal relationship. between cause and effect has been clearly established and it is possible to predict. very accurately the course of events in the future, once the future patterns of causes are inferred from past behaviour. Economic systems, however, are more complex because (i) there is a large number of governing factors in a complex structural framework which may not be possible to identify and (ii) the individual factors themselves have a high degree of variability and uncertainty. The demand for a particular product (say umbrellas) would depend on competitor's prices, advertising campaigns, weather conditions, population and a number of factors which might even be difficult to identify. In spite of these complexities, a forecast has to be made so that the manufacturers of umbrellas (a product which exhibits a seasonal demand) can plan for the next season.

Forecasting for Planning Decisions

The primary purpose of forecasting. is to provide valuable information for planning the design and operation of the enterprise. Planning decisions may be classified as long term, medium term and short term.

Long term decisions include decisions like plant expansion or. new product introduction which may require new technologies or a. complete transformation in social or moral fabric of society. Such decisions are generally, characterised by lack of quantitative information and absence of historical data on which to base, the forecast of future events. Intuition and the collected opinion of. experts in the field generally play a significant role in developing forecasts for such decisions. Some methods used in forecasting for long term decisions are discussed in Section 17.2.

Medium term decisions involve such decisions as planning the production levels in a manufacturing plant over the next year, determination of manpower requirements or inventory policy for the firm. Short term decisions include daily production planning and scheduling decisions. For both medium and short term forecasting, many methods and techniques exist. These methods can broadly be classified as follows

a) Subjective of intuitive methods.

b) Methods based on averaging of past data, including simple, weighted and moving averages.

c) Regression models on historical data.

d) Causal of Econometric models.

e) Time series analysis or stochastic models.

These methods are briefly reviewed in Section 17.3. A more detailed discussion of correlation, regression and time series models is taken up in the next three units.

The choice of an appropriate forecasting method is discussed in Section 17.4.. The aspect of forecast control which tells whether a particular method in use is acceptable is discussed in Section 17.5. And finally a summary is given in Section 17.6.

17.2 FORECASTING FOR LONG TERM DECISIONS

Technological Forecasting

Technological growth is often haphazard, especially in developing countries like India. This is because Technology seldom evolves and there are frequent technology transfers -due to imports of knowhow resulting in a leap-frogging phenomenon. In spite of this, it is generally seen that logarithms of many technological variables show linear trends with time, showing exponential growth. Some extrapolations reported by Rohatgi et al. (10) are

- Passenger kms carried by Indian Airlines (Figure I)
- Fertilizer applied per hectare of cropped area (Figure II)
- Demand and supply of petroleum crude (Figure III)
- Installed capacity of electricity generation in millions of KW (figure IV).

Figure I: Passenger Km Carried by Indian Air Lines

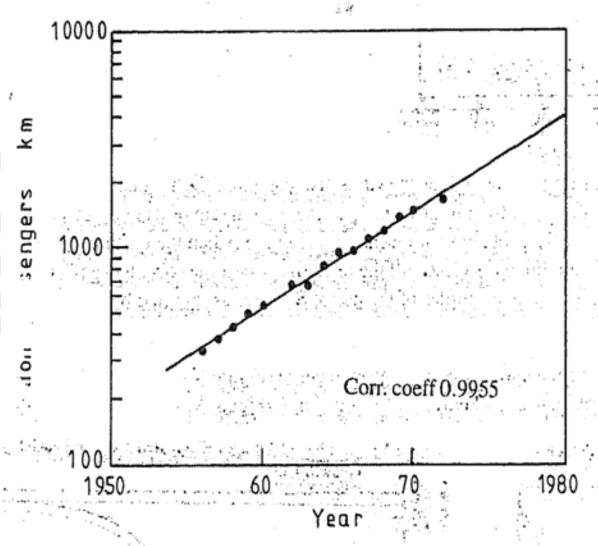


Figure II: Fertilizer Applied per Hectare of Cropped Area

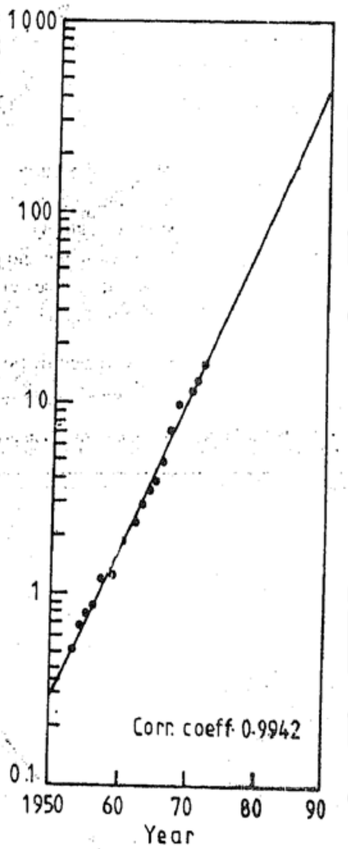


Figure III: Demand and Supply of Petroleum Crude

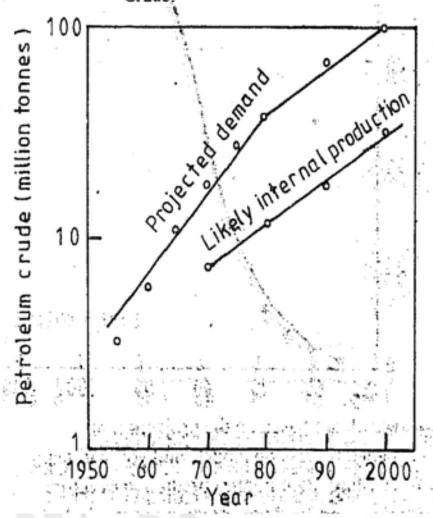
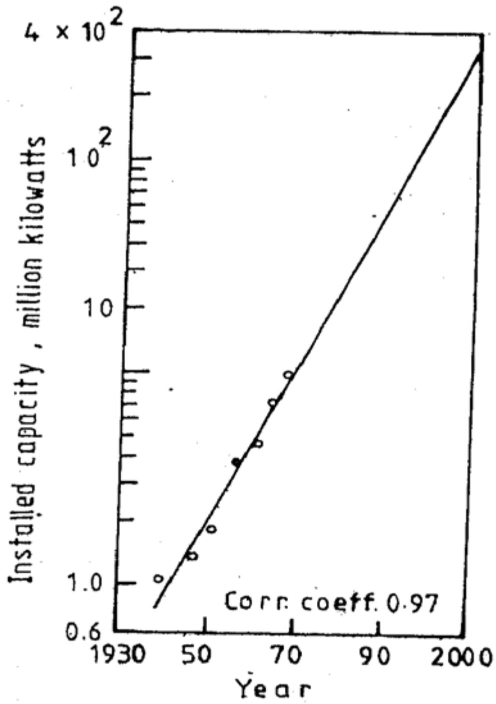


Figure IV: Installed Capacity of Electricity Generation in Million KW



The use of S curves in forecasting technological growth is also common. Rather than implying unchecked growth there is a limit to growth. Thus the growth rate of technology is slow to begin with (owing to initial problems), it reaches a maximum (when the technology becomes stable and popular) and finally declines till the technology becomes obsolete and is replaced by a newer alternative. Some examples of the use of S curves as reported by Rohatgi et al. (1979) are

- Hydroelectric power generation using Gumpertz growth curve (Figure V)
- Number of villages electrified using a Pearl type growth curve (Figure VI).

Figure V: Hydroelectric Power Generation Using Gompertz Growth Curve

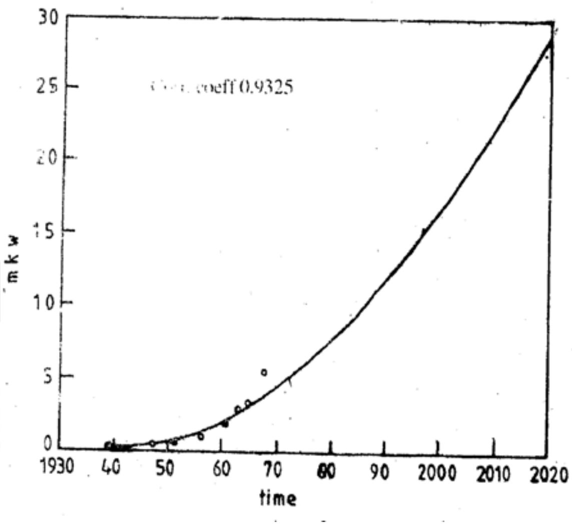
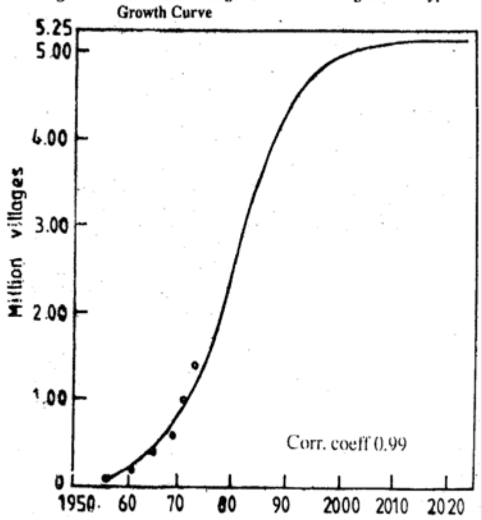


Figure VI: Number of Villages Electrified Using a Pearl Type Growth Curve



Apart from the above extrapolative techniques which are based on the projection of historical data into the future (such models are called regression models and you will learn more about them in Unit 19), technological forecasting often implies prediction of future scenarios or likely possible futures. As an example suppose there are three events E,; E_2 and E_3 where each one may <u>or</u> may not happen in the future. Thus, eight possible scenarios-E,

$E_{2\ E3,}$ E_1 E_2 E_3, E, $_{E2}$ E_3, E; E_2 E_3,, E_2 E_3; E, E_2 E_3, E, E_2 E_3,, E_2 E_3 -show the range of possible futures (a line above the event indicates that the event does not take place). Moreover these events may not be independent. The breakout of war (E_1) is likely to lead to increased spendings on defence (E_2) and reduced emphasis on rural uplift and social development (E_3). Such interactions can be investigated using the Cross-impact Technique. For details you may refer to Martino (8).

Delphi

This is a subjective method relying on the opinion of experts designed to minimise bias and error of judgment. A Delphi panel consists of a number of experts with an impartial leader or coordinator who organises the questions.

Specific questions (rather than general opinions) with yes-no or multiple type answers or specific dates/events are sought from the experts. For instance, questions could be of the following kind :

- When do you think the petroleum reserves of the country would be exhausted? (2000, 2020, 2040)
- When would the level of pollution in Delhi exceed danger limit? (as defined by a particular agency)?
- What would the population of India be in 1990, 2000 and 2010?
- When would fibre optics become a commercial viability for communication?

A summary of the responses of the participants is sent to each expert participating in the Delphi panel after a statistical analysis. For a forecast of when an event is likely to happen, the most optimistic and pessimistic estimates along with a distribution of other responses is given to the participant. On the basis of this information the experts may like to revise their earlier estimates and give revised estimates to the coordinator. It may be mentioned that the identities of the experts are not revealed to each other so that bias or influence by reputation is kept to a minimum. Also the feedback response is statistical in nature without revealing who made which forecast. The Delphi method is an iterative procedure in which revisions are carried out by the experts till the coordinator gets a stable response.

The method is very efficient, if properly conducted, as it provides a systematic framework for collecting expert opinion. By virtue of anonymity, statistical analysis and feedback of results and provision for forecast revision, results obtained are free of bias and generally reliable. Obviously, the background of the experts and their knowledge of the field is crucial. This is where the role of the coordinator in identifying the proper experts is important.

Opinion Polls

Opinion polls are a very common method of gaining knowledge about consumer tastes, responses to a new product, popularity of a person or leader, reactions to an election result or the likely future prime minister after the impending polls. In any opinion poll two things are of primary importance. First, the information that is sought and secondly the target population from whom the information is sought. Both these factors must be kept in mind while designing the appropriate mechanism for conducting the opinion poll. Opinion polls may be conducted through

- Personal interviews.
- Circulation of questionnaires.
- Meetings in groups.
- Conferences, seminars and symposia.

The method adopted depends largely on the population, the kind of information desired and the budget available. For instance, if information from a very large number of people is to be collected a suitably designed questionnaire could be mailed to die people concerned. Designing a proper questionnaire is itself a major task. Care should be taken to avoid ambiguous questions. Preferably, the responses should be short one word answers or ticking an appropriate reply from a set of multiple choices. This makes the questionnaire easy for the respondent to fill and also easy for the analyst to analyse. For example, the final analysis could be summarised by saying

80% of the population expressed opinion A

10% expressed opinion B

5% expressed opinion C

5% expressed no opinion

Similarly in the context of forecasting of product demand, it is common to arrive at the sales forecast by aggregating the opinion of area salesmen. The forecast could be modified based on some kind of rating for each salesman or an adjustment for environmental uncertainties.

Decisions in the area of future R&D or new technologies too are based on the opinions of experts. The Delphi method treated in this Section is just an example of a systematic gathering of opinion of experts in the concerned field.

The major advantage of opinion polls lies in the fact that a well formed opinion considers the multifarious subjective and objective factors which may not even be possible to enumerate explicitly, and yet they may have a bearing on the concerned forecast or question. Moreover the aggregation of opinion polls tends to eliminate the bias that is bound to be present in any subjective, human evaluation. In fact for long term decisions, opinion polls of opinions of the experts constitute a very reliable method for forecasting and planning.

17.3 FORECASTING FOR MEDIUM AND SHORT TERM DECISIONS

Forecasting for the medium and short term horizons from one to six months ahead is commonly employed for production planning, scheduling and financial planning decisions in an organisation. These methods are generally better structured as compared to the models for long term forecasting treated in Section 17.2, as the variables to be forecast are well known and often historical data is available to guide in the making of a more reliable forecast. Broadly speaking we can classify these methods into five categories.

i) Subjective of intuitive methods.

ii) Methods based on an averaging of past data (moving average and exponential smoothing).

iii) Regression models on historical data.

iv) Causal or econometric models.

v) Stochastic models, with Time Series analysis and Box-Jenkins models.

Subjective or Intuitive Methods

These methods rely on the opinion of the concerned people and are quite popular in practice. Top executives, salesmen, distributors, and consumers could all be approached to give an estimate of the future demand of a product. And a judicious aggregation/adjustment of these opinions could be used to arrive at the forecast of future demand. How such opinion polls could be systematically conducted has already been discussed in Section 17.2. Committees or even a Delphi panel could be constituted for the purpose. However, all such methods suffer from individual bias and subjectivity. Moreover the underlying logic of forecast generation remains mysterious for it relies entirely on the intuitive judgment and experience of the forecaster. It cannot be documented and programmed for use on a computer so that no matter whether A or B or C makes the forecast, the result is the same. The other categories of methods discussed in the section are characterised by well laid procedures so that documentation and computerisation can be easily done.

However, subjective and intuitive methods have their own advantages. The opinion of an expert or an experienced salesman carries with it the accumulated wisdom of experience and maturity which may be difficult to incorporate in any explicit mathematical relationship developed for purposes of forecasting. Moreover in some instances where no historical data is available (e.g. forecasting the sales of a completely new product or new technology) reliance on opinions of persons in Research and Development, Marketing or other functional areas may be the only method available to forecast and plan future operations.

Methods Based on Averaging of Past Data (Moving Averages and Exponential Smoothing)

In many instances, it may be reasonable to forecast the demand for the next period by taking the average demand till date. Similarly when the next period demand actually becomes known, it would be used in making the forecast of the next future period. However, rather than use the entire past history in determining the average. Only the recent data for the past 3 or 6 months may be used. This is the idea behind the `Moving Average', where only the demand of the recent couple of periods (the number of periods being specified) is used in making a forecast. Consider, for illustration, the monthly sales figures of an item, shown in Table 1.

Table 1
Monthly Sales of an Item and Forecasts Using Moving Averages

Month	Demand	3 period moving Average	6 period moving Average
Jan	199		
Feb	202		
Mar	199	200.00	
Apr	208	203.00	
May	212	206.33	
Jun	194	203.66	202.33
July	214	205.66	207.83
Aug	220	208.33	210.83
Sept	219	216.66	213.13
Oct	234	223.33	217.46
Nov	219	223.00	218.63
Dec	233	227.66	225.13

The average of the sales for January, February and March is (199+202+199)/3=200, which constitutes the 3 months moving average calculated at the end of March and may thus be used as a forecast for April. Actual sales in April turn out to be 208 and so the 3 months moving average forecast for May is (202+199+208)/3 =203. Notice that a convenient method of updating the moving average is

$$\text{New moving average} = \text{Old moving average} + \frac{\left\{\begin{matrix}\text{Added}\\ \text{period}\\ \text{demand}\end{matrix} - \begin{matrix}\text{Dropped}\\ \text{period}\\ \text{demand}\end{matrix}\right\}}{\text{Number of periods in moving average}}$$

At the end of May, the actual demand for May is 212, while the demand for February which is to be dropped from the last moving average is 202. Thus,

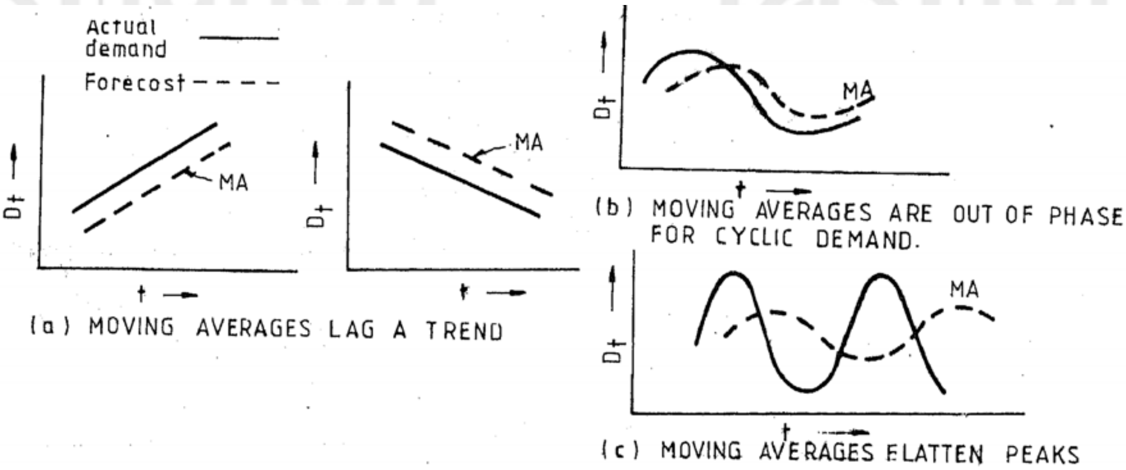
New moving average = 203 + 10/3 = 206.33 which is the forecast for June. Both the 3 period and 6 period moving average are shown in Table 1.

It is characteristic of moving averages to

a) Lag a trend (that is, give a lower value for an upward trend and a higher value for a lower trend) as shown in Figure VII (a).

b) Be out of phase (that is, lagging) when the data is cyclic, as in seasonal demand. This is depicted in Figure VII (b).

c) Flatten the peaks of the demand pattern as shown in Figure VII (c).



(a) MOVING AVERAGES LAG A TREND

(b) MOVING AVERAGES ARE OUT OF PHASE FOR CYCLIC DEMAND.

(c) MOVING AVERAGES FLATTEN PEAKS

Some correction factors to rectify the lags can be incorporated. For details, you may refer to Brown (3).

Exponential smoothing is an averaging technique where the weightage given to the past data declines (at an exponential rate) as the data recedes into the past. Thus all the values are taken into consideration, unlike in moving averages, where all data points prior to the period of the Moving Average are ignored.

If F_t is the one-period ahead forecast made at time t and is the demand for period t, then

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

Where α is a smoothing constant that lies between 0 and 1 but generally chosen values lie between 0.01 and 0.30. A higher value of a places more emphasis on recent data. To initiate smoothing, a starting value of F_t, is needed which is generally taken as the first or some average demand value available. Corrections for trend effects may be made by using double exponential smoothing and other factors. For details, you may consult the references at the end.

A computation of the smoothed values of demand for the example considered earlier in Table 1 is shown in Table 2 for values of a equal to 0.1 and 0.3. In these computations, exponential smoothing is initiated from June with a starting forecast as the average demand for the first five months. Thus the error for June is (194-204), that is -10, which when multiplied by a (0.1 or 0.3 as the case may be) and added to the previous forecast of 204 yields 203 or 201 (depending on whether α is 0.1 or 0.3) respectively as shown in Table 2.

Table2

Monthly Sales of an Item and Forecasts Using Exponential Smoothing

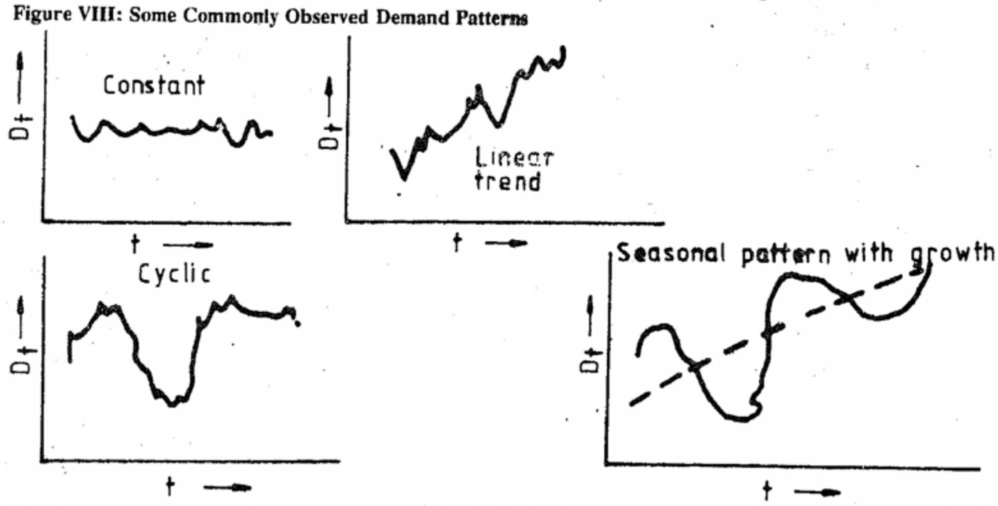
Month	Demand	Smoothed forecast (alpha = 0.1)	Smoothed forecast (alpha = 0.3)
Jan	199		
Feb	202		
Mar	199		
Apr	208		
May	212		
Jun	194	204.0	204.0
July	214	203.0	201.0
Aug	220	204.1	204.9
Sept	219	205.7	209.4
Oct	234	207.0	212.3
Nov	219	209.7	218.8
Dec	233	210.6	218.9

Both moving averages and smoothing methods are essentially short term forecasting techniques where one or a few period-ahead forecasts are obtained.

Regression Models on Historical Data

The demand of any product or service when plotted as a function of time yields a time series whose behaviour may be conceived of as following a certain pattern with random fluctuations. Some commonly observed demand patterns are shown in Figure VIII.

Figure VIII: Some Commonly Observed Demand Patterns



The basic approach in this method is to identify an underlying pattern and to fit a regression line to demand history by available statistical methods. The method of least squares is commonly used to determine the parameters of the fitted model.

Forecasting by this technique assumes that the underlying system of chance causes which was operating in the past would continue to operate in the future as well. The forecast would thus not be valid under abnormal conditions like wars, earthquakes, depression or other natural calamities like floods or drought which might drastically affect the variable of interest.

For the demand history considered previously in Tables 1 and 2, the linear regression line is $F_t = 193+3t$

where t = l refers to January, t=2 to February, and so on. The forecast for any month t can be found by substituting the appropriate value oft. Thus, the expected demand for next January (t=13) = 193 + (3 x 13) = 232.

You will study details of this regression procedure in Unit 19. We may only add here that the procedure can be used to fit any type of function, be it linear, parabolic or other, and that some very useful statements of confidence and precision can also be made.

Causal or Econometric Models

In causal models, an attempt is made to consider the cause effect relationships and the variable of interest (e.g. demand) is modelled as a function of these causal variables. For instance, in trying to forecast the demand of tyres of a particular kind in a certain month (say DTM), it would be reasonable to assume that this is influenced by the targeted production of new vehicles for that month (TPVM) and the total road mileage of existing vehicles in the past 6 months (say) which could be assumed to be proportional to sales of petrol in the last 6 months (SPL6M). Thus, one possible model to forecast the monthly demand of tyres is DTM=a x (TPVM) + b x (SPL6M) + where a, b and c are constants to be determined from the data. The above model has value for forecasting only if TPVM and SPL6M (the two causal variables) are known at the time the forecast is desired. This requirement is expressed by saying that these variables be leading. Also the quality of it is determined by the correlation between the predictor and the predicted variables. Commonly used indicators of the economic climate, such as consumers price index, wholesale price index, gross national product, population and per capital income are often used in econometric models because these are easily available from published records.

Model parameters are estimated by usual regression procedures, similar to the ones described in Models on Historical Data :

Construction of these structural and econometric models is generally difficult and more time-consuming as compared to simple time-series regression models. Nevertheless, they possess the advantage of portraying the inner mechanics of the demand so that when changes in a certain pertinent factor occur, the effect can be predicted.

The main difficulty in causal models is the selection or identification of proper variables which should exhibit high correlation and be leading for effective forecasting.

Time Series Analysis or Stochastic Models

The demand or variable of interest when plotted as a function of time yields what is commonly called a `time-series'. This plot of demand at equal time intervals may show random patterns of behaviour and our objective in Models on Historical Data was to identify the basic underlying pattern that should be used to explain the data. After hypothesising a model (linear, parabolic or other) regression was used to estimate the model parameters, using the criterion of minimising the sum of squares of errors.

Another method often used in time series analysis is to identify the following four major components in a time series.

i) Secular trend (e.g. long term growth in market)

ii) Cyclical fluctuation (e.g. due to business cycles)

iii) Seasonal variation (e.g. Woollens, where demand is seasonal)

iv) Random or irregular variation.

The observed value of the time series could then be expressed as a product (or some other function) of the above factors.

Another treatment that may be given to a time series is to use the framework developed by Box and Jenkins (1976) in which a stochastic model of the autoregressive (AR) variety, moving average (MA) variety, mixed autoregressive-moving average variety (ARMA) or an integrated autoregressive-moving average variety (ARIMA) model may be chosen. An introductory discussion of these models is included in Unit 20. Stochastic models are inherently complicated and require greater efforts to construct. However, the quality of forecasting generally improves. Computer codes are available to implement the procedures [see for instance Box and Jenkins (1976)].

17.4 FORECAST CONTROL

Whatever, be the system of forecast generation, it is desirable to monitor the output of such a system to ensure that the discrepancy between the forecast and actual values of demand lies within some permissible range of random variations.

A system of forecast generation is shown in Figure IX.

From past data, the system generates a forecast which is subject to modification through managerial judgment and experience. The forecast is compared with the current data when it becomes available and the error is watched or monitored to assess the adequacy of the forecast generation system.

The Moving Chart is a useful statistical device to monitor and verify the accuracy of a forecasting system.

The control chart is easy to construct and maintain. Suppose data for n periods is available. If F_t is the forecast for period t and D_t is the actual demand for period t then MR (Moving

Range) $= |(F_t - D_t) - (F_{t-1} - D_{t-1})|$

$$\therefore \overline{MR} = \frac{\Sigma MR}{n-1} \text{ (There are } n-1 \text{ moving averages for } n\text{-periods)}$$

Then Upper Control Limit (UCL) $= +2.66\,\overline{MR}$

Lower Control Limit (LCL) $= -2.66\,\overline{MR}$

The variable to be plotted on the chart is the error $(F_t - D_t)$ in each period. A sample control chart is shown in Figure X. Such a control chart tells three important things about a demand pattern:

Figure IX: System of Forecast Generation

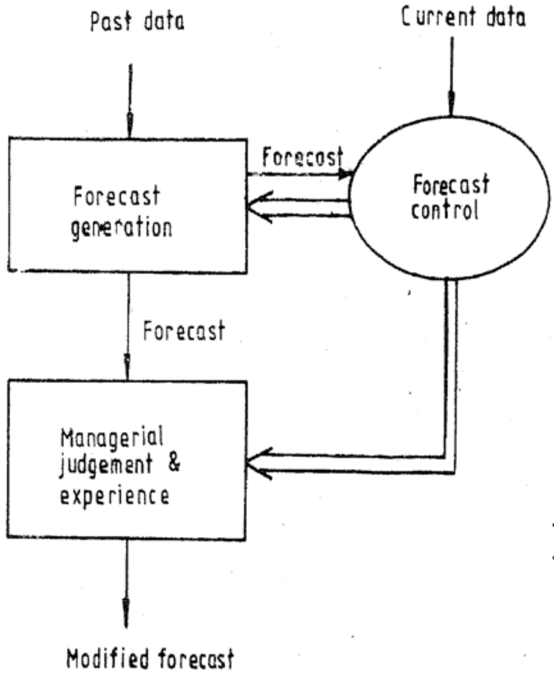
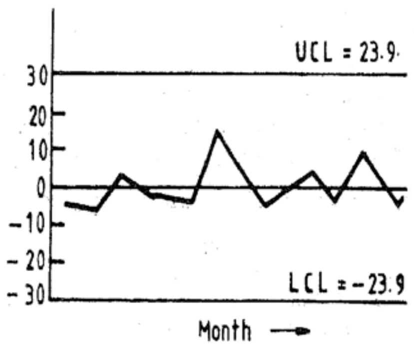


Figure X: A Control Chart Based on Moving Range



(Control chart for a sample situation

a) whether the past demand is statistically stable,

b) whether the present demand is following the past pattern,

c) if the demand pattern has changed, the control chart tells how to revise the forecasting method.

As long as the plotted error points keep falling within the control limits, it shows that the variations are due to chance causes and the underlying system of forecast generation is acceptable. When a point goes out of control there is reason to suspect the validity of the forecast generation system, which should be revised to reflect these changes.

17.5 SUMMARY

The unit has emphasised the importance of forecasting in all planning decisions-be they long term, medium term or short term. For long term planning decisions, techniques like Technological Forecasting, collecting opinions of experts as in Delphi or opinion polls using personal interviews or questionnaires have been surveyed. For medium and short term decisions, apart from subjective and intuitive methods there is a greater variety of mathematical models and statistical techniques that could be profitably employed. There are methods like Moving averages or exponential smoothing that are based on averaging of past data. Any suitable mathematical function or curve could be fitted to the demand history by using least squares regression. Regression is also used in estimation of parameters of causal or econometric models. Stochastic models using Box-Jenkins methodology are a statistically advanced set of tools capable of more accurate forecasting. Finally, forecast control is very necessary to check whether the forecasting system is consistent and effective. The moving range chart has been suggested for its simplicity and ease of operation in this regard.

17.6 SELF-ASSESSMENT EXERCISES

1 Why is forecasting so important in business? Identify applications of forecasting for

- Long term decisions.
- Medium term decisions.
- Short term decisions.

2 How would you conduct an opinion poll to determine student reading habits and preferences towards daily newspapers and weekly magazines?

3, 4, 5 For the demand data of a product, the following figures for last year's sales (monthly) are given :

Period (Monthly)

1	2	3	4	5	6	7	8	9	10	11	12
80	100	79	98	95	104	80	98	102	96	115	88
67	53	60	79	102	118	135	162	70	53	68	63
117	124	95	228	274	248	220	130	109	128	125	134

a) Plot the data on a graph and suggest an appropriate model that could be used for forecasting.

b) Plot a 3 and 5 period moving average and show on the graph in (a)

c) Initiate exponential smoothing from the first period demand for smoothing constant (cc) values of 0.1 and 0.3. Show the plots.

6 What do you understand by forecast control? What could be the various methods to ensure that the forecasting system is appropriate?

17.7 KEY WORDS

Causal Models: Forecasting models wherein the demand or variable or interest is related to underlying causes or causal variables.

Delphi: A method of collecting information from experts, useful for long term forecasting. It is iterative in nature and maintains anonymity to reduce subjective bias.

Exponential Smoothing: A short term forecasting method based on weighted averages of past data so that the weightage declines exponentially as the data recedes into the past, with the highest weightage being given to the most recent data.

Forecasting: A systematic procedure to determine the future value of a variable of interest.

Moving Average: An average computed by considering the K most recent (for a K-period moving average) demand points, commonly used for short term forecasting.

Prediction: A term to denote the estimate or guess of a future variable that may be arrived at by subjective hunches or intuition.

Regression: From a given demand history to establish a relation between the dependent variable (such as demand) and independent variable (S). Such relations prove very useful for forecasting purposes.

Time Series: Any data on demand, sales or consumption taken at regular intervals of time constitutes a time series. Analysis of this time series to discover patterns of growth, decay, seasonalities or random fluctuations is known as to Time Series analysis.

17.8 FURTHER READINGS

Biegel, J.E., 1974. *Production Control-A Quantitative Approach,* Prentice Hall of India: New Delhi.

Box, G.E.P. and G.M. Jenkins, 1976. *Time Series Analysis: Forecasting and Control,* I-lolden-Day: San Francisco.

Brown, R.G., 1963. *Smoothing, Forecasting and Prediction of Discrete Time Series,* Prentice Hall: Englewood-Cliffs.

Chambers, J.C., S.K. Mullick and D.D. Smith, 1974. *An Executive's Guide to Forecasting,* John Wiley: New York.

Firth, M., 1977. *Forecasting Methods in Business and Management,* Edward Arnold: London.

Jarrett, Al, 1987. *Forecasting for Business Decisions,* Basil Blackwell: London.

Makridakis, S. and S. Wheelwri^g^ht, 1978. *Forecasting: Methods and Applications,* John Wiley: New York.

Martino. J.P., 1972. *Technological Forecasting for Decision Making,* American Elsevier: New York, .

Montgomery D.C. and L.A. Johnson, 1976. *Forecasting and Time Series Analysis, McGraw* Hill: New York.

Rohatgi. P.K., K. Rohatgi and B. Bowonder, 1979. *Technological Forecasting,* Tata McGraw Hill: New Delhi.