OM4 –Sales and operations planning

Module II

MODELS OF FORECASTING

Forecasting –

Forecasting is the process of making predictions or estimates about future events based on past and present data, trends, and patterns. It is widely used in various fields including economics, finance, business, weather, and technology, among others, to anticipate future outcomes and make informed decisions

Forecasting methods can be classified into two groups: qualitative and quantitative Qualitative forecasting methods, often called judgmental methods, are methods in which the forecast is made subjectively by the forecaster. They are educated guesses by forecasters or experts based on intuition, knowledge, and experience. When you decide, based on your intuition, that a particular team is going to win a baseball game, you are making a qualitative forecast. Because qualitative methods are made by people, they are often biased.

Quantitative forecasting methods, on the other hand, are based on mathematical modeling. Because they are mathematical, these methods are consistent

Qualitative Forecasting method –

Qualitative forecasting methods rely on subjective judgments, expert opinions, and qualitative data rather than numerical data or statistical techniques. These methods are often used when historical data is limited, unreliable, or unavailable, or when there are significant uncertainties about future conditions. Qualitative forecasting methods include:

1. **Expert Opinion**: This method involves gathering insights and predictions from individuals or groups with expertise or experience relevant to the forecasted subject. Experts may include industry professionals, consultants, academics, or stakeholders who provide informed opinions based on their knowledge and judgment.

2. **Delphi Method**: The Delphi method is a structured approach to gather and distill the opinions of a panel of experts. Participants provide forecasts anonymously in multiple rounds, with a facilitator summarizing and circulating the results of each round to the group. The process continues until a consensus or convergence of opinions is reached.

3. **Market Research and Surveys**: Market research techniques, including surveys, focus groups, and customer interviews, can be used to gather qualitative data about consumer preferences, behaviors, and expectations. This information can be used to make qualitative forecasts about future market trends, demand for products or services, and customer preferences.

4. **Scenario Analysis**: Scenario analysis involves developing and analyzing multiple hypothetical scenarios or future states based on different sets of assumptions and variables. This qualitative method helps decision-makers

explore a range of possible outcomes and understand the potential impacts of various factors on the forecasted subject.

5. **Historical Analogy**: Historical analogy involves using past events or historical data as analogs or references to forecast future outcomes. Decision-makers identify similar past situations and use them as a basis for predicting how current events or trends may unfold in the future. This method relies on the assumption that history repeats itself to some extent.

6. **Judgmental Forecasting**: Judgmental forecasting encompasses various qualitative techniques that rely on the judgment and intuition of decision-makers or forecasters. These methods may include brainstorming sessions, intuitive judgment, or group discussions to generate forecasts based on subjective assessments of future conditions.

Qualitative forecasting methods are particularly useful in situations where quantitative data is limited or unreliable, or when there is a high degree of uncertainty or complexity involved in the forecasting process. However, they are also subject to biases, subjective interpretations, and uncertainties inherent in human judgment. Therefore, it's essential to use qualitative forecasting methods in conjunction with other techniques and to critically evaluate the reliability and validity of the forecasts generated.

Quantitative forecasting methods

Quantitative forecasting methods involve using mathematical models and statistical

techniques to analyze historical data and make predictions about future events or trends. These methods rely on numerical data and patterns derived from historical observations to forecast future outcomes. Some common quantitative forecasting methods include:

I. Time Series Model of Forecasting:

Time series analysis is a statistical technique used to analyze historical data points collected over time, such as daily sales figures, monthly revenue, or annual GDP growth. This method examines patterns, trends, and seasonal variations in the data to forecast future values. Techniques commonly used in time series analysis include moving averages, exponential smoothing, and autoregressive integrated moving average (ARIMA) models.

Time series models of forecasting require past data to fulfill objective of prediction. This type of data is recorded over a period of time taken at regular intervals (e.g. hourly, weekly, monthly, annually). The data collected over a selected time period can be regarding sales of a product, absenteeism rate, operating time on a machine, profits etc. For example, sales figures collected over a period of four weeks can be used to predict sales of fifth week.

The most important aspect to understand is the time interval for which data has to be collected. Should a particular data be collected hourly, daily, weekly, monthly or at any other rate? Data fluctuation is directly proportional to time interval selected. It can show a trend, seasonal, cyclical or random variation. The fluctuation behavior of data would be instrumental in deciding proper forecasting technique. Time intervals are always discussed in relative sense. Terms such as short, medium and long term are relative to the context in which they are used.

Also selected time period has an influence over accuracy of prediction. If the data is collected for a very long term period it might provide good results but older data may not have relevance in present scenario. Likewise, if only recent data is used it might not be sufficient to give reliable prediction results. Thus, time period and availability of data over that time period influences accuracy of forecasting.

In previous modules we have discussed four ways in which data can fluctuate. These methods have been briefed here with some illustrations.

- ***Seasonal:*** Amount of traffic increases twice every day and shows similar pattern next working day. So, data regarding traffic will show a repetitive cycle with equal time intervals.
- ***Cyclical:*** Fashion keeps on changing with one style of clothing which had gone out of fashion would again be considered in vogue. But this happens at irregular time intervals where it is very difficult to predict when one style will go out of fashion and when it will reappear.
- ***Trend:*** A mobile phone company might see an upward trend of sale of their smart phones over last six- eight months but with competitor launching a new variant the company's sale might start to slow down weekly. So, the sale of smart phones showed an increasing trend over monthly data whereas decrease in sale of smart phones showed a decreasing trend over weekly data.
- ***Random:*** Fluctuation of a share in stock market shows an irregular trend and its fluctuation is recorded hourly or even at smaller time period.

Steps in Time Series Forecasting:

1. **Data Collection:**
   - Gather historical data on the variable of interest.

- Ensure data is collected at regular intervals.

2. **Data Preprocessing:**

- Handle missing values, outliers, and inconsistencies.
- Ensure data stationarity if required.

3. **Exploratory Data Analysis (EDA):**

- Analyze the time series data to identify trends, seasonality, and other patterns.

4. **Model Selection:**

- Choose an appropriate time series model based on the characteristics of the data.
- Consider ARIMA, Exponential Smoothing, or other advanced models.

5. **Model Training:**

- Use historical data to train the selected model.

6. **Model Validation:**

- Validate the model's accuracy using a holdout set or cross-validation.

7. **Forecasting:**

- Use the trained model to make future predictions.

8. **Model Evaluation:**

- Evaluate forecasting accuracy using metrics

9. **Continuous Monitoring:**

- Periodically update the model with new data to ensure it remains accurate.

Challenges in Time Series Forecasting:

- Seasonal Changes: Seasonal variations can make accurate forecasting challenging.
- External Factors: External factors such as economic conditions or policy changes may influence the time series.

Applications in Operations Management:

- Inventory Management: Helps optimize inventory levels based on anticipated demand.
- Production Planning: Aids in planning production schedules to meet future demand.
- Supply Chain Management: Enables better coordination along the supply chain by predicting demand for raw materials and finished goods.

II. Moving average model forecasting

A moving average model is used for forecasting future values, while moving average smoothing is used for estimating the trend-cycle of past values. Two examples of data from moving average models with different parameters.

The moving average model is a time series forecasting method that calculates the average of a specified number of past observations to predict future values.

Purpose:

- Smoothes out short-term fluctuations.
- Useful for identifying trends and patterns in data.

Types of Moving Averages:

1. **Simple Moving Average (SMA):**

- Equal weights are assigned to all observations in the moving average window.
- Useful for smoothing out noise and identifying trends.

2. **Weighted Moving Average (WMA):**

- Assigns different weights to different observations.
- More recent observations may be given higher weights.

3. **Exponential Moving Average (EMA):**

- Assigns exponentially decreasing weights to past observations.
- Reacts more quickly to recent changes.

Advantages:

- Simple to understand and implement.
- Effective in smoothing out short-term fluctuations.

Limitations:

- May not capture sudden, significant changes in the time series.
- Sensitivity to the choice of the moving average window size.

Steps in Implementing Moving Average Model:

1. **Data Collection:**
   - Collect historical data on the variable of interest.
2. **Determine Moving Average Type:**
   - Choose between Simple Moving Average (SMA), Weighted Moving Average (WMA), or Exponential Moving Average (EMA) based on the characteristics of the data.
3. **Select Moving Average Window:**

- Determine the number of past observations to include in the moving average window.

4. **Calculate Moving Average:**
    - Apply the chosen moving average formula to calculate the average.
5. **Forecasting:**
    - Use the calculated moving average to predict future values.
6. **Model Evaluation:**
    - Assess the forecasting accuracy using metrics such as Mean Absolute Error (MAE) or Mean Squared Error (MSE).

Applications in Operations Management:

1. **Demand Forecasting:**
    - Predict future demand for products to optimize inventory levels.
2. **Sales Forecasting:**
    - Estimate future sales to plan production and marketing strategies.
3. **Resource Planning:**
    - Plan resource allocation based on predicted future values.
4. **Quality Control:**
    - Monitor and control product quality by anticipating variations.

Challenges:

- Choosing an appropriate window size can be subjective and might require experimentation.
- Limited ability to capture sudden changes or outliers in the time series.

Example Calculation:

Let's say the historical sales data for the past 24 months (in units) is as follows:

Month	Sales
Month 1	100
Month 2	110
Month 3	120
...	...
Month 24	180

Now, we calculate the moving average for each month using a window size of 3 months:

For Month 4: Moving Average = (100 + 110 + 120) / 3 = 110

For Month 5: Moving Average = (110 + 120 + New Data) / 3

...

For Month 24: Moving Average = (New Data + Last 2 Data) / 3

We repeat this process for each subsequent month to generate a forecast for future demand.

Forecast Evaluation:

After generating the forecasted demand for future months, we evaluate its accuracy by comparing it with the actual sales data for those months. Metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), or Root Mean Squared Error (RMSE) can be used to assess the accuracy of the forecast.

Overall, the moving average model provides a simple yet effective method for forecasting demand or other relevant variables in operations research scenarios, allowing businesses to make informed decisions about inventory management,

production planning, and resource allocation.

III. Causal method

Causal method is both quantitative forecasting techniques used in economics and related fields to analyze the relationships between variables and make predictions about future outcomes.

Causal methods, also known as causal forecasting, involve identifying and analyzing causal relationships between variables to predict future values. These methods rely on the assumption that changes in one variable (the independent variable) cause changes in another variable (the dependent variable). Causal forecasting typically involves the following steps:

Identify Causal Relationships: Determine which variables are likely to have a causal effect on the variable of interest based on theoretical knowledge, empirical evidence, or data analysis.

Collect Data: Gather historical data on the relevant variables, including the independent variable(s) and the dependent variable.

Model Specification: Specify a mathematical model that represents the causal relationship between the variables. This model could be linear or nonlinear, depending on the nature of the relationship.

Estimation: Estimate the parameters of the model using statistical techniques such as ordinary least squares (OLS) regression, instrumental variables, or structural equation modeling.

Forecasting: Once the model parameters are estimated, use the model to forecast future values of the dependent variable based on projections of the independent variable(s).

Example: A causal method could be used to forecast the demand for a product based

on factors such as price, income levels, advertising expenditure, and seasonality. A regression model could be specified where demand is the dependent variable, and price, income, advertising, and seasonality are independent variables.

Types of Causal Forecasting Models:

1. **Linear Regression:**

- Assumes a linear relationship between the dependent and independent variables.
- Simple linear regression involves one independent variable, while multiple linear regression involves multiple independent variables.

2. **Non-linear Regression:**

- Allows for more complex relationships between variables.

3. **Econometric Models:**

- Incorporates economic factors into the forecasting model.

4. **Input-Output Models:**

- Commonly used in production and economic forecasting.

Challenges:

- Data Quality: The accuracy of the forecasts depends heavily on the quality of data used.
- Assumption of Causality: Causal relationships assumed in the model may not always accurately reflect real-world complexities.

IV. Econometric Models:

Econometric models are a specific type of causal model used in economics to analyze economic relationships and make predictions. Econometric models are typically based on economic theory and use statistical techniques to estimate the parameters of the model. These models are often used to test economic theories,

evaluate policy interventions, and forecast economic variables.

The econometric methods combine statistical tools with economic theories to estimate economic variables and to forecast the intended economic variables. An econometric model may be single equation regression model or it may consist of a system of simultaneous equations.

Regression method

Regression analysis is the most popular method of demand estimation. This method combines economic theory and statistical techniques of estimation. Economic theory is employed to specify the determinants of demand and to determine the nature of the relationship between the demand for a product and its determinants. Economics theory thus helps in determining the general form of demand function. Statistical techniques are employed to estimate the values of parameters in the estimation equation.

Simultaneous Equation Method

It involves estimating several behavioural equations. These equations are generally behavioural equations, Mathematical equations and Market – clearing equations. The first step in this technician is to develop a complete model and specify the behavioural assumption regarding the variables included in the model. The variables that are included in the model are

1. Endogenous variables
2. Exogenous variables

Endogenous variables – the variables that are determined within the model are called endogenous variables. Endogenous variables are included in the model as depended variables that are the variables that are to be explained by the model. These are also called controlled variables. The number of equations included in the model must be equal to number of endogenous variables.

Exogenous variables – are those that are determined outside the model. Exogenous variables are inputs of the model whether a variable is treated endogenous variables or exogenous variables depend on the purpose of the model. The examples of exogenous variables are "Money Supply", tax rates, govt. spending etc. The exogenous variables are also known as uncontrolled variables.

Econometric models can be classified into different types, including:

Structural Models: These models are based on economic theory and attempt to explicitly represent the structural relationships between economic variables. Structural models are used to analyze the effects of policy changes or economic shocks on the economy.

Reduced-Form Models: Reduced-form models do not explicitly represent the underlying economic relationships but instead focus on statistically estimating the relationship between variables. These models are often used for forecasting and prediction.

Time Series Models: Time series econometric models are specifically designed to analyze time series data and make predictions about future values of economic variables. These models include autoregressive integrated moving average (ARIMA) models, vector autoregression (VAR) models, and others.

Example: An econometric model could be used to forecast GDP growth based on factors such as government spending, interest rates, inflation, and international trade.

The model would specify the relationship between GDP growth and the independent variables based on economic theory and estimate the parameters using statistical techniques.

In summary, both causal methods and econometric models are valuable tools in economics and related fields for analyzing relationships between variables and making predictions about future outcomes. Causal methods focus on identifying and modeling causal relationships, while econometric models use statistical techniques to estimate parameters and make predictions based on economic theory