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B.Com Honours

Semester I

Calicut University

Essential Statistics for Business Analytics

Course Code: COM1MN109 • Module 4 Notes

1. Time Series Analysis: Objectives, Uses, and Components

In business analytics, predicting future values—such as next quarter's sales, stock prices, or raw material demand—is critical for operational planning. A time series is a set of quantitative observations recorded at successive, equally spaced intervals of time. Time series analysis models these historical patterns to project future values. This final module covers the components of a time series, trend measurement techniques (Freehand, Semi-Averages, Moving Averages), and the mathematical Method of Least Squares.

Objectives and Uses of Time Series

- **Forecasting:** Projecting future operations to guide budgeting, inventory management, and capacity planning.
- **Evaluating Progress:** Comparing actual business performance against historical trends.
- **Analyzing Seasonal Demand:** Identifying periodic spikes (e.g., festival sales) to adjust production runs.

Components of a Time Series

A time series observation is assumed to result from four distinct components:

Secular Trend (T)

The long-term, smooth upward or downward movement of the series over multiple years (e.g., population growth, technology adoption).

Seasonal Variations (S)

Short-term, periodic fluctuations that repeat within a single year (e.g., ice cream sales rising in summer, umbrella sales in monsoon).

Cyclical Variations (C)

Medium-to-long term wave-like oscillations corresponding to business cycles (prosperity, recession, depression, recovery).

Irregular Variations (I)

Random, unpredictable fluctuations caused by sudden external events (e.g., wars, floods, pandemics, strikes).

Mathematical Models of Time Series

- **Additive Model:** Assumes components act independently.
[$Y = T + S + C + I$]
- **Multiplicative Model:** Assumes components are interdependent (most widely used in business).
[$Y = T \times S \times C \times I$]

2. Trend Measurement Techniques

Freehand and Semi-Averages Methods

- **Freehand Graphic Method:** Plotting the time series data on a graph and drawing a smooth, subjective line through the points. *Limitations:* Highly subjective, depends entirely on the analyst's judgment.
- **Method of Semi-Averages:** Dividing the time series data into two equal halves. The arithmetic mean of each half is calculated. These two mean points are plotted on the graph and connected with a straight line, which represents the trend. *Advantages:* Objective and simple, but assumes the trend is strictly linear.

Moving Averages Method

This method smooths out short-term seasonal and irregular fluctuations. The trend value for a year is the average of data points of surrounding years. Odd-period moving averages (3-year, 5-year) are centered directly on the middle year. Even-period moving averages (4-year) require centering by taking the average of two successive 4-year moving averages to align with specific years. *Limitations:* Loses data points at the beginning and end of the series.

3. Method of Least Squares (Linear Trend Fitting)

The Method of Least Squares is a mathematical technique used to fit a straight-line trend to time series data, satisfying the condition that the sum of squared residuals is minimized. The

trend line equation is:

$$[Y = a + bX]$$

Where: **Y** = Trend value, **X** = Time variable (coded), **a** = Y-intercept (value of Y when X = 0), **b** = Slope of the line (rate of change per unit of time).

Normal Equations

To find the values of *a* and *b*, we solve two normal equations:

$$[\sum Y = na + b \sum X]$$

$$[\sum XY = a \sum X + b \sum X^2]$$

Simplification (Origin Shifting)

By shifting the origin of time (*X*) to the middle of the time series, we can make ($\sum X = 0$). This simplifies the normal equations significantly, allowing direct calculations:

$$[a = \frac{\sum Y}{n}]$$

$$[b = \frac{\sum XY}{\sum X^2}]$$

Example Application

For a 5-year dataset ($n=5$, years 2020-2024), we set the origin to the middle year (2022). The coded values for *X* become: -2, -1, 0, 1, 2. Since ($\sum X = 0$), we calculate *a* and *b* directly, establishing a line to forecast future years (e.g., setting $X = 3$ for year 2025).

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