Importance of Business Forecasting

- In marketing, total demand for products must be forecasted in order to plan total promotional effort.
- In finance, interest rates must be predicted so that new capital acquisitions can be planned and financed.
- In personnel management, forecasts of the number of workers required in different job categories are required in order to plan job recruiting and training programs.
- In production scheduling, predictions of demand for each product line for specific weeks and months allow the firm to plan production schedules and inventory maintenance.
- In process control, forecasts of the behavior of the industrial process in the future are required so that the number of defective items produced can be minimized.

Types of Forecasting Techniques

- Qualitative Forecasting Methods
- Quantitative Forecasting Methods

Qualitative Forecasting Methods

- These methods are used when historical data are scarce or not available at all.
- They generally use expert opinion to predict future events subjectively.
- Advantage
  - useful when historical data either are not available or are scarce. For example, sales of new product, environment and technology over the long term.
- Disadvantage
  - Subjective

Quantitative Forecasting Methods

- These methods are used when historical data are available.
- They generally construct a forecasting model from available data or theory to do forecasts.
- Advantage
  - Objective. Once the underlying model or technique has been chosen, the corresponding forecasts are determined automatically. They are fully reproducible by any forecaster.
- Disadvantage
  - Need data
**Time Series/Univariate Methods**
- The objective of the time series methods is to discover the pattern in the past values of a variable. Assuming that the historical pattern will continue, this method extrapolate it into the future and use it to predict future values of the variable of interest.
- **Advantage**
  - require historical data of one variable only; useful when historical data pattern does not change
- **Disadvantage**
  - cannot evaluate the impact of changes in other variables.

**Causal/Multivariate Methods**
- Make use of the relationship between the variable to be forecast and the other variables that explains its variation to do the forecast.
- **Advantage**
  - can evaluate the impact of changes in other variables.
- **Disadvantages**
  - difficult to identify other variables.
  - require historical data on all variables of the model.
  - depend on the future values of the other variables.

**What is a Time Series?**
- A time series is a series of observations on a particular variable collected over a period of time (usually at equally spaced intervals).
- **Examples of time series data**
  - daily stock price, exchange rates, mean temperature
  - monthly sales, money supply, production, inventory level
  - quarterly GDP
  - annually population

**Time-Series Components**
- Trend
- Cyclical
- Seasonal
- Irregular

**Trend Component**
- Overall upward or downward movement
- Data taken over a period of years

**Cyclical Component**
- Upward or downward swings
- May vary in length
- Usually lasts 2 - 10 years
**Seasonal Component**
- Upward or downward swings
- Regular patterns
- Observed within 1 year

**Random or Irregular Component**
- Erratic, nonsystematic, random, "residual" fluctuations
- Due to random variations of
  - Nature
  - Accidents
- Short duration and non-repeating

**Forecast Error Analysis**
- Random errors
- Cyclical effects not accounted for
- Trend not accounted for
- Seasonal effects not accounted for

**Accuracy Measures**
- Forecast error or residual $e_t = Y_t - F_t$
- Mean error $ME = \frac{1}{n} \sum e_t$
- Mean absolute error $MAE = \frac{1}{n} \sum |e_t|$
- Mean squared error $MSE = \frac{1}{n} \sum e_t^2$

**Accuracy Measures**
- Percentage error $PE_t = \left( \frac{e_t}{Y_t} \right) \times 100$
- Mean percentage error $MPE = \frac{1}{n} \sum PE_t$
- Mean absolute percentage error $MAPE = \frac{1}{n} \sum |PE_t|$
Naive Model

- Assume that recent period are the best predictors of the future

\[ F_{t+1} = Y_t \]

**Example:** Sales of ovens for the ABC company (1994-2000)

<table>
<thead>
<tr>
<th>Year</th>
<th>Quarter 1</th>
<th>Quarter 2</th>
<th>Quarter 3</th>
<th>Quarter 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>500</td>
<td>350</td>
<td>250</td>
<td>400</td>
</tr>
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<td>1999</td>
<td>750</td>
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<td>400</td>
<td>650</td>
</tr>
<tr>
<td>2000</td>
<td>850</td>
<td>600</td>
<td>450</td>
<td>700</td>
</tr>
</tbody>
</table>

\[ F_{25} = Y_{24} = 650 \]

Naive Trend Model

- Estimate trend by taking the difference between this and last period

\[ F_{t+1} = Y_t + (Y_t - Y_{t-1}) \]

**Example**

\[ F_{25} = Y_{24} + (Y_{24} - Y_{23}) \]
\[ = 650 + (650 - 400) \]
\[ = 900 \]

Naive Rate of Change Model

- For some purposes, the rate of change might be more appropriate than the absolute amount of change

\[ F_{t+1} = Y_t \left( \frac{Y_t}{Y_{t-1}} \right) \]

**Example**

\[ F_{25} = Y_{24} \left( \frac{Y_{24}}{Y_{23}} \right) \]
\[ = 650 \left( \frac{650}{400} \right) \]
\[ = 1056 \]

Naive Seasonal Model

- Next quarter the variable will take on the same value it did in the corresponding quarter 1 year ago

\[ F_{t+1} = Y_{t-3} \]

**Example**

\[ F_{25} = Y_{21} = 750 \]

Naive Trend and Seasonal Model

- The \( Y_{t-3} \) term forecasts the seasonal patterns and the remaining term averages the amount of change for the past 4 quarters (trend).

\[ F_{t+1} = Y_{t-3} \left( \frac{(Y_{t-2} - Y_{t-3}) + \cdots + (Y_{t} - Y_{t+3})}{4} \right) \]
Naive Trend and Seasonal Model

Example

\[ F_{22} = \frac{5}{4} \left( (Y_{2,2} - Y_{2,1}) + (Y_{2,3} - Y_{2,2}) + \cdots + (Y_{2,5} - Y_{2,4}) \right) \]

\[ = \frac{750 + 650 - 600}{4} \]

\[ = 762.5 \]

Theil’s U-statistic

- This statistic allows a relative comparison of formal forecasting methods with naïve approaches and also squares the errors involved so that large errors are given much more weight than small errors.

Definition of Theil’s U-statistic

\[ U = \sqrt{\frac{\sum_{t=1}^{n-1} \left( \frac{(F_{t,t+1} - Y_{t,t+1})}{Y_{t,t+1}} \right)^2}{\sum_{t=1}^{n-1} \left( \frac{(Y_{t,t+1} - Y_{t+1})}{Y_{t+1}} \right)^2}} \]

Interpreting Theil’s U-statistic

- \( U = 1 \): The naïve method is as good as the forecasting technique being evaluated.
- \( U < 1 \): The forecasting technique being used is better than the naïve method. The smaller the U-statistic, the better the forecasting technique is relative to the naïve method.
- \( U > 1 \): There is no point in using a formal forecasting method, since using a naïve method will produce better results.