Demand forecasting

Demand Forecasts -Forecasting methods

- **Qualitative**
  - Personal opinion
  - Panel consensus
  - Delphi method
  - Market research (rapid appraisal)
  - Historical comparison

- Quantitative methods
  - Time series
    - Freehand method
    - Smoothing methods
    - Exponential smoothing methods
    - Trend projection methods
    - Trend projection adjusted for seasonal influence
  - Causal
    - Linear regression model

Quantitative forecasting methods

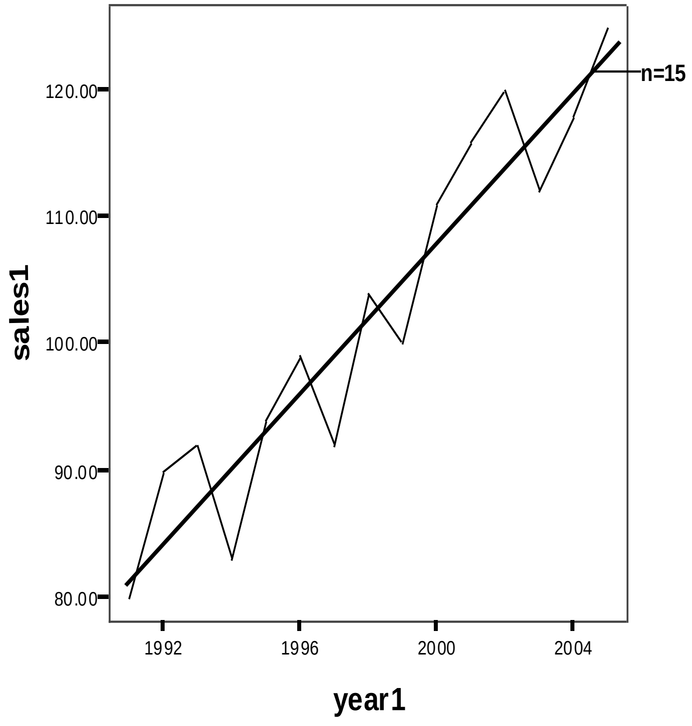
- A few time series methods such as freehand curves and moving averages simply describe the given data values, while other methods such as semi-average and least squares help to identify a trend equation to describe the given data values.
- A freehand curve drawn smoothly through the data values is often an easy and perhaps adequate representation of the data.

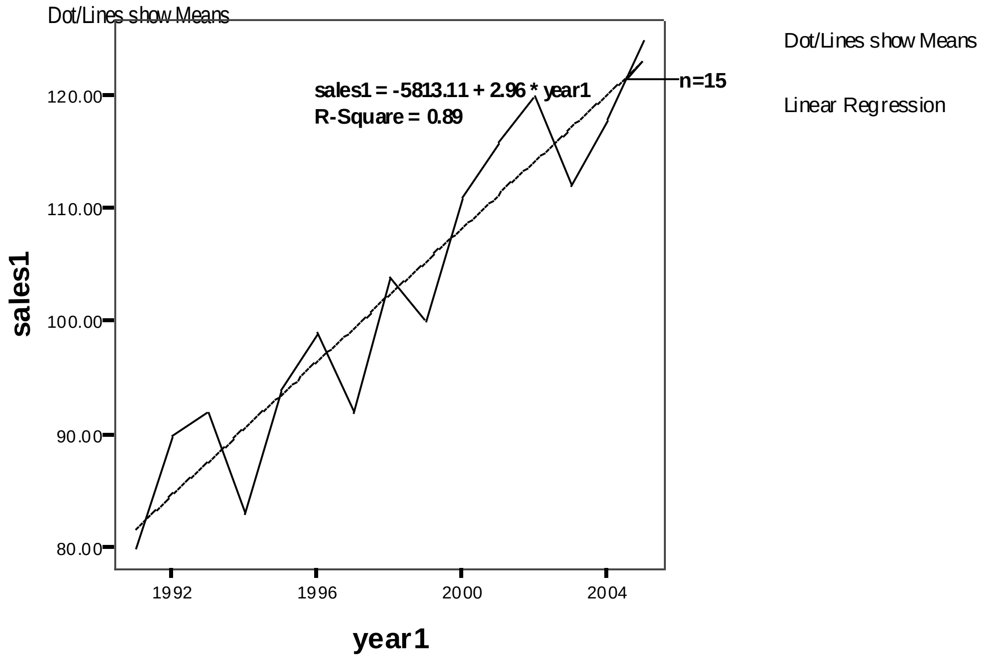
Freehand method

- The forecast can be obtained simply by extending the trend line. A trend line fitted this way should conform to the following:
  - The trend line should be smooth – a straight line or mix of long gradual curves.
  - The sum of the vertical deviations above the trend line should be equal to the sum of vertical deviations below the trend line.
  - The sum of the squares of the vertical deviations of the observations from the trend line should be as small as possible.
  - The trend line should bisect the cycles so that area above the trend line should be equal to the area below the trend line, not only for the entire series bus as much as possible for each full cycle.

Freehand method

- Example from SPSS sale 1.


n=15
120.00
110.00
100.00
90.00
80.00
sales1
1992
1996
2000
2004
year1


Dot/Lines show Means
sales1 = -5813.11 + 2.96 * year1
R-Square = 0.89
n=15
120.00
110.00
100.00
90.00
80.00
sales1
1992
1996
2000
2004
year1
Dot/Lines show Means
Linear Regression

Freehand method

- Limitations
  - Highly subjective; a good fit for someone may not be so for another.
  - The trend line drawn cannot have much value if used as a basis for predictions.
  - It is very time consuming if a careful and meticulous job is to be done.

Smoothing methods

- Smoothing methods – are to smoothen out the random variations due to irregular components of the time series and thereby provide us with an overall impression of the pattern of movement in the data over time.
  - Common methods
    - Moving averages
    - Weighted moving averages
    - Semi-averages
    - Simple exponential smoothing
    - Adjusted exponential smoothing

Moving averages method

- Moving averages method
  - A subjective method that depends on the length of the period chosen for calculating moving averages.
  - To remove the effect of cyclical variations, the period chosen should be an integer value that corresponds to or is a multiple of the estimated average length of a cycle in the series.

Moving averages method

- The moving averages which serve as an estimate of the next period's value of a variable given a period length ***n*** is expressed as:

$$MA_{t+1} = \frac{\sum \left\{ D_t + D_{t-1} + D_{t-2} + \ldots + D_{t-n+1} \right\}}{n}$$

- t = current time
- D = actual data which is exchanged each period
- n = length of smoothing time period

Moving averages method

- Moving averages method – limitations
  - It is highly subjective and dependent on the length of period chosen for constructing the averages. MAs have the following general limitations
    - As the size of ***n*** increases, it smoothens the variations better, but it also makes the method less sensitive to real changes in the data.
    - Moving averages cannot pickup trends very well. Since these are averages, it will always stay within past levels and will not predict a change to either a higher or lower level.
    - Moving average requires extensive records of past data.

Moving averages method

- No moving average can be obtained for the first **(n-1)/2** year or the last **(n-1)/2** year of the series. Thus for a 5-year moving average, we cannot make computations for the first two years or the last two years of the series.
- Example.

Weighted moving average (WMA)

- In moving averages, each observation is given equal importance. However, different values might have different importance merely, for instance, due to the time difference.
- Choice of weights is somewhat arbitrary because there is no set formula to determine them.
- In most cases, the most recent observation receives the highest weight and the weight decreases for older observations.

Weighted moving average (WMA)

- WMA can be expressed mathematically as:

$$WMA = \frac{\sum (weight\ \ for\ \ period\ n)(Data\ value\ in\ period\ n)}{\sum weights}$$

- Example: Herbicide sales data for 12 months are given below. The supplier plans to forecast sales by weighting the past three months as follows:

Weight	Month
3	Last month
2	Two months ago
1	Three months ago
6	

Weighted moving average (WMA)

- Forecast for the current month

$$= \frac{3 * last\,month + 2 * sales\ two\,months\ ago + 1 * sales\ three\ months\ ago}{6}$$

- Excel.

Semi-Average Method

- Permits us to estimate the slope and intercept of the trend line quite easily if a linear function adequately describes the data.
- Procedure
  - Divide the series in to two and compute their respective arithmetic means.
  - Plot these two points corresponding to their midpoint of the class interval covered by the respective part.
  - Connect these points with a straight line; i.e., the trend line.

Semi-Average Method

- The arithmetic mean of the first part is the intercept value, and the slope is determined by the ratio of the difference in the arithmetic mean to the number of years between them, that is the change per unit time.
- The result is a time series of the form **$\hat{y}=a+bx$.**
- **Example – fitting a trend line for the seed data in excel using the semi-average method and forecasting the sales for 2002.**

Exponential Smoothing Method (ESM)

- ESM is a type of moving average forecasting technique which weighs past data in an exponential manner so that the most recent data carries more weight in the moving average.
- Simple exponential smoothing makes no explicit adjustment for trend effects whereas adjusted exponential smoothing does so.

ESM – Simple ESM

- In simple ESM – the forecast is made up of the last period forecast plus a portion of the difference between the last period's actual demand and the last period's forecast.

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

- F_t is current period forecast
- F_{t-1} is last period forecast
- α is a smoothing constant ($0 \le \alpha \le 1$)
- D_{t-1} last period actual demand

ESM – Simple ESM

- Implications of α,
  - If it is low, more weight is given to previous forecast.
  - When it is high, more weight is given to previous actual demand.
  - If it were assigned a value as high as 1, each forecast would reflect total adjustment to the recent demand and the forecast would simply be last period's actual demand, that is $F_t = D_{t-1}$.
  - Since demand fluctuations are typically random, the value of α is generally kept in the range of 0.005 and 0.3 in order to "smooth" the forecast.
  - The exact value depends upon the response to demand that is best for the individual firm.

ESM – Simple ESM

- The correct α value facilitates scheduling by providing a reasonable reaction to demand without incorporating too much random variation. An approximate value of α which is equivalent to an arithmetic moving average, in terms of degree of smoothing, can be estimated as

$$\alpha = 2/(n+1).$$

- The accuracy of forecasting model can be determined by comparing the forecasted values with the actual or observed values.
- **Forecast error = Actual values – forecasted values**

ESM – Simple ESM

- One measure of the overall forecast error for a model is the mean absolute deviation (MAD).

$$\text{MAD} = \frac{\sum \left|\text{forecast errors}\right|}{n}$$

- Where ***n*** is number of periods and standard deviation (σ) ≈ 1.25 MAD.
- The ESM facilitates continuous updating of the estimate of MAD. The current MAD_i is given by

$$MAD_t = \alpha \left| Actual\ values - forecasted\ values \right| + (1-\alpha) MAD_{t-1}$$

- Higher values of α make the current MAD more responsive to current forecast errors.

ESM – Simple ESM

- Example: A VISIONARY firm uses simple exponential smoothing with $\alpha = 0.1$ to forecast demand. The forecast for the week of February 1 was 500 units whereas actual demand turned out to be 450 units.
- Questions
  - 1. forecast the demand for the week of February 8.
  - Assume the actual demand during the week of February 8 happened to be 505 units. Forecast the demand for the week of February 15. Continue forecasting through March 15, assuming that the subsequent demands were actually 516, 488, 467, 554 and 510 units.
  - Excel!

Adjusted Exponential Smoothing

- The simple exponential smoothing model is highly flexible because the smoothing effect can be increased or decreased by lowering or raising the value of α.
- However, if a trend exists in the data, the series will always lag behind the trend. Thus for an increasing trend the forecasts will be consistently low and for decreasing trends they will be consistently high.
- Simple exponential smoothing forecasts may be adjusted $(F_t)_{adj}$ for trend effects by adding a trend smoothing factor β to the calculated forecast value F_t.

Adjusted Exponential Smoothing

$$(F_t)_{adj} = F_t + \frac{1-\beta}{\beta} T_t$$

- $(F_t)_{adj}$ = trend adjusted forecast
- F_t = simple exponential smoothing forecast
- β = smoothing constant
- T_t = exponentially smoothed trend factor
- High β is more responsive to recent changes in trend. A low β gives less weight to the most recent trends and tends to smooth out the present trend.
- Values of β can be found by the trial and error method , with the MAD used as a measure of comparison.

Adjusted Exponential Smoothing

- The value of the exponentially smoothed trend factor (T_t) is computed as

$$T_t = \beta(F_t - F_{t-1}) + (1-\beta)T_{t-1}$$

- Where T_{t-1} is last period trend factor.
- Example: Develop an adjusted exponential forecast for the VISIONARY firm discussed above.
- Assume the initial trend adjustment factor (Tt-1) is zero and $\beta=0.1$
- Example – Excel.