# Class 8 – Forecasting – 2017-10-06

## Reading Ch8 233-238; Ch10 274-299; Centered Moving Average Spreadsheet

### Introduction

* **Applications of Forecasting**
  + Management: marketing, production, operations; inventory, logistics, purchasing; strategic & operational planning
  + Financial/Economic Analysts: public/private sector; forecasting interest %, share $, volatility, GNP, sector growth
  + IT professionals: system demand planning

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| **Forecasting Methods** | | |
| **Qualitative** | **Quantitative** | |
| Surveys  Sales Force Composites  Executive Consensus  Delphi (expert consensus)  Outside Opinions (consult)  Historical & Test Marketing | **Time Series (Extrapolation)**  **-Naïve**: Next value = Past average  **1.Moving Average**: For randomness only; smooths everything out; only 1 period ahead  **2.Exponential Smoothing**: Same as MA but more sophisticated  **3.Classical Decomposition**: Series separated into trend, cyclical, and seasonal components  i. **Seasonal Relatives:** Seasonal indicies only  ii: **Time Series Analysis**: T, S, C; look at periods ahead | **Casual**  **1.Simple Regression**: X to predict Y  **3.Multiple Regression**: X,Z… to predict Y  **3.Econometrics**: Multiple equations, time series variables (eg: price per gallon of gas) |

* **Economic Indicators**
  + Leading Indicators: Economic series that change in adv. of economy (big ticket items, employment, financial)
  + Coincident Indicators: Change with the economy (GDP, production index, personal income, retail sales)
  + Lagging Indicators: Confirming change in economy (loans, U/E rate, labour cost, level of inventory, inflation)

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| **Factors in Choosing a Forecasting Model** | **Model Selection** | **Forecasting Procedure** |
| * **Resources**: Time, $, Expertise * **Accuracy Required** * **Availability of Data**: Historical, other * **Understanding of Environment**: dependent vs independent variables * **Nature of product/service being forecast** and expected pattern * **Time span** * **Impulse Response** * **Noise Dampening** | 1. **Nature of the problem:** Qualitative vs Quantitative (Time series vs Casual) 2. **Plot Data** to determine nature of the relationship 3. **Identify Time Series Components** 4. Use observations to **develop competing forecasting models** 5. **Run models** on rest of observations 6. **Calculate accuracy** of each model 7. **Select model with best accuracy measure** | 1. Determine objectives re: forecast (use) 2. Select items to be forecast 3. Determine time horizon (short,med,long) 4. Select forecasting model(s) 5. Gather data 6. Validate forecasting model (using actual time series)    * MAD, MAE, MSE, RMSE, MAPE 7. Make forecast 8. Implement results; Monitor |

### Time Series

* **Time Series**: variable measured over time in sequential order; must be analyzed to detect **Patterns**

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| **Time Series Components** | | | | |
| **Base (B)** | **Long Term Trend (T)** | **Cyclical Effect (C)** | **Season Effect (S)** | **Random Variation (R)** |
| Past average; starting point; “level component” | Smooth pattern/ direction; persists > 1yr | Wavelike pattern; persists >1yr; appear in combination with other components | -Short term repetitive behaviour <1yr  Day 🡪 Wk 🡪 7/5  Day 🡪 Mth 🡪 28-31  Wk 🡪 Mth 🡪 4  Wk 🡪 Yr 🡪 52  Mth 🡪 Yr 🡪12  Qtr 🡪 Yr 🡪 4 | Irregular, unpredictable; **Cannot be forecast;** Try to remove & identify other components |
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| 1. **Additive Time Series Model** 2. **Multiplicative Model:** | | | | |

### Data Smoothing Techniques

* Purpose: To produce a better forecast, must determine what components are present (also a forecasting method)
  + To identify components must reduce/remove random variation 🡪 Always expect some RV
  + Be wary of “over-smoothing”

### Forecasting (using Smoothing Techniques)

* **1. Moving Average Forecasting (See above - B only)**
  + Averaging fluctuations in time to identify the underlying direction; assuming future will be similar to recent past; short range applications
  + “k” period moving average for time period “t”; note lose k-1 values – no data!
    - **Simple Moving Average:** equal weighting on each period
    - **Weighted Moving Average:** often more weight towards more recent data
  + **Values:** **Chosen** based technical and managerial judgement, experience, skill; can use EXCEL to check errors (see below & textbook p284)
  + ***EXCEL****: Tools 🡪 Data Analysis 🡪 Moving Average*
  + **Issues:** 
    - Weekly period removes daily variation; Monthly 🡪 daily/weekly; Yearly 🡪 D/W/M/Seasonal; etc.; Do you want to remove random variation + seasonality & cycles?
    - Mathematically, moving averages will lag behind 🡪 Centered Moving Average?
  + **Forecasting Application**: Random only, no trend, cyclical, or seasonal effects; short range only (t+1)
* **2. Forecasting with Exponential Smoothing (B only)**
  + More sophisticated than MA; provides a decreasingly weighted average of **all** past part-time data series
  + “St” smoothed time series at time “t” by smoothing time series “yt” by constant “α” + previously smoothed time series “St-1”. Use first period value (yo) for S-1.
  + **Values: Chosen** based technical and managerial judgement, experience, skill; can use EXCEL to check errors (see below & textbook p284)
    - α = between 0 and 1 and weighs the historical data; start high and roll down with more info avail.
    - **Large α** 🡪 faster **impulse** response; erratic issues vs **Small α** 🡪 long lags reacting to change
  + ***EXCEL****: Tools 🡪 Data Analysis 🡪 Exponential Smoothing (Excel Dampening Factor = 1 -α)*
  + **Issues:** Oversmoothing; does not identify trends; eliminates some past data; must decide where to place averages in table/graph (which period)
  + **Forecasting Application**: Random only, no trend, cyclical, or seasonal effects; short range only (t+1)

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| **Exponential Smoothing vs Moving Average**   * ES provides smoothed values over **all** time periods; MA does not provide values for initial and/or final periods * ES considers all data available prior to “t”; MA only considers observations within average value t to t-k+1 |

* ***Extensions*** *(available in Forecasting software packages)*
  + ***Holt’s Method for Trend (B,T):*** *Uses 2 smoothing constants α - noise & β - trend*
  + ***Winter’s Model for Seasonality (B,T,S):*** *Uses 3 smoothing constants α - noise, β – trend, & γ – seasonality*

### 3. Seasonality: Seasonal Relative Method (B,S)

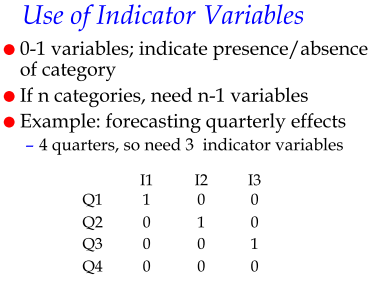
* 1. **Identify seasons** (week/month; month/year; qtr/year)
* 2. Computer **average per season** over # of years (use centered moving average if trend exists)
* 3. For each period, compute **seasonal indices** by dividing actuals by seasonal average
* 4. Average seasonal indices / normalize to identify **seasonal factor**
* 5. **Apply** to forecast

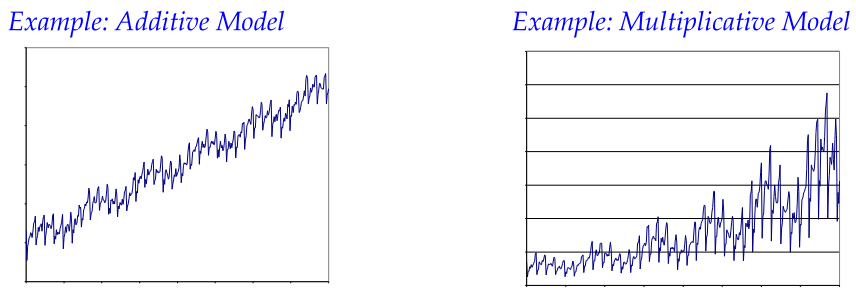


### Forecasting using Regression Techniques: Trend Component

* **4. Trend Analysis (B,T)**
  + Trend component of time series can be linear or non-linear; isolate trend component using linear regression
  + Start with Scatter Plot
    - **i. Linear Trend:**  – **Linear Regression (Class 3 & 4)**
    - **ii. Non-Linear Trend (with 1 change):**

### Forecasting using Regression Techniques: Seasonality

* **5. Trend and Seasonality Analysis (B,T,S)**
  + Use linear regression (bo and b1 from regression model) to forecast time series with **trend** and **seasonality**
    - **i. Multiplicative Model (S\*)** 
      * SIt: **Seasonal Index** for period t
      * ***Most real data is multiplicative*** *(ie Sales)*
    - **ii. Additive Model (S+)** 
      * b2S1, b3S2, b4S3: **Indicator “Dummy” Variables** (regression)



### Forecasting with Correlated Data (Autoregressive Models)

* Autocorrelation among errors (*ie large observations follow large observation; small observations follow small*) of a regression model provides opportunity to produce accurate forecasts; correlation between consecutive residuals leads to the following (ie providing weight to historical errors) **6. Autoregressive Model**
* **Identifying Autocorrelation:** 
  + Maintain Regression Analysis assumptions: error terms are normally distributed about mean = 0 with standard deviation over all values of independent variables
  + Look at histogram of error terms (standard residuals)
  + Plot errors vs predicted Y and see if there is a pattern
  + Can also do correlation analysis for 1,2,…. lags **(ie use lagging Y-values as X variables)**

### Evaluating Forecast Accuracy

* Evaluate forecast using actual available time series
  + Mean Absolute Deviation (MAD):
    - *Less effected by extreme observations*
    - or Mean Absolute Error (MAE): *MAD?*
  + **Mean Squared Error (MSE):** 
    - *Penalizes large errors due to larger impact of squaring – error aren’t changing much , every error is important*
  + Root Mean Squared Error (RMSE):
    - *Prescribed in same units as the data (similar to STDEV)*
  + Mean Absolute Percent Error (MAPE):
    - *Unitless for relative comparisons (profs preferred method) – huge level changes, check %*

### Combining Forecasts

* Research looking at combining forecasts indicate 2-3 is sufficient across any model; averaging the values for each forecast when calculating combined forecast

### Reasons for Ineffective Forecasting

* Not involving broad cross section of people
* Not recognizing forecasting is integral to business planning
* Not recognizing forecasts will always be wrong
* Not forecasting the right things
* Not selecting appropriate method
* Not tracking accuracy of forecasting model

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| **Time Series Components** | | | **Models** |
| **B** | No T | No S | * **Exponential Smoothing** * **Simple Moving Average** |
| **B** | No T | **S+** | * **Time Series Regression** with dummy variable for season*(****take time out*** *of the model & be aware of autoregressive models)* |
| **B** | No T | **S\*** | * **Moving Average** over Season Period to remove seasonality & estimate seasonal index factors |
| **B** | **T** | No S | * **Time Series Regression***(be aware of autoregressive models)* * **Holt’s 2 Parameter** Smoothing |
| **B** | **T** | **S+** | * **Time Series Regression** with seasonal dummy variables |
| **B** | **T** | **S\*** | * **Option 1 – Classical Decomposition**    + **Centered Moving Average** over seasonal period to remove seasonality   + Calculate **Seasonal Indexes**   + **Time-series regression** on de-seasonalized data   + Forecast by **re-seasonalizing** fitted Data * **Winter’s 3 Parameter** Smoothing |
| ***S+*** *- Seasonal Additive* ***S\**** *- Seasonal Multiplicative*  ***Noise****: As values get bigger, swings get bigger but not necessarily seasonality!* | | | |
| ***Verify forecast using holdout sample, if available; otherwise check using measures of goodness (MSE, MAD, MAPE)*** | | | |