


Lesson 05 – Forecasting & Smoothing Methods




Lesson 05

Forecasting & Smoothing Methods


Forecasting is the process of predicting the future

The forecast is the basis for business decisions involving

- . Financial
- . Production
- . Inventory
- . Personnel
- . Facilities




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How do you decide what to produce when you don't know what your customers will buy?

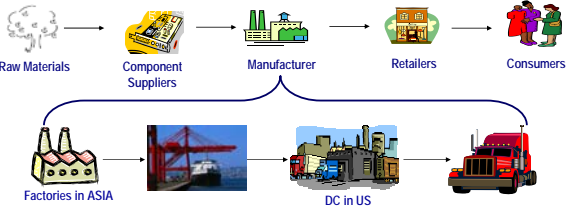
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Products differ

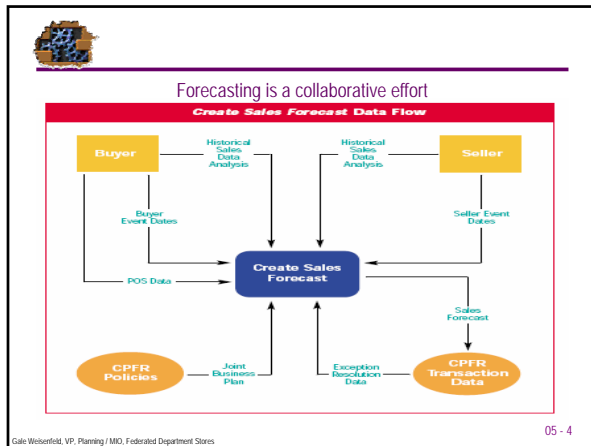


Supply Chains and Strategies differ



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Forecasting Facts

There are several facts that are true about forecasting.

- Those businesses that adopt a forecasting discipline do better than those who do not
- Of those that forecast, those who do it "better" are typically more successful
- Forecasting provides direction for an organization detailed functional activities

There is an old saying "if you do not know where you are going then any road you take will get you there". Forecasting provides a road for each functional area of the organization to follow.

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Functional Areas and Forecasting

Organization

Finance	Operations	Marketing
Determines the revenue to be generated and the operating costs associated with the schedules to produce a financial P/(L) forecast for stock holders, bankers, and executive management	Warehousing can plan staffing for stocking/shipping Production looks at demand and on-hand inventory to develop a schedule and determine capacity requirements to meet demand and maintain safety stock Purchasing can use the schedule to notify suppliers of dates raw materials are needed	Initiates the forecast in \$ or units (typically) Manages the forecasting process

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Forecast, Production Plan and Inventory

Simplistically, once the future demand is forecasted,

	6 Month Forecast					
	1	2	3	4	5	6
Forecast Demand	10	8	12	14	10	8

a manufacturing production plan is developed,

Production Plan	10	10	10	12	12	10
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resulting in an inventory plan


Inventory	10	10	12	10	8	10	12
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which can be evaluated against financial objectives. If inventory is too *high*, plan alternatives must be considered.

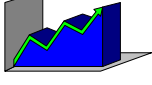
This course will deal with each of these operational functions.

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Forecasting Techniques

Simple  Sophisticated

 *Computer Systems* 


Quantitative Mathematical/Statistical Methods 

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Forecasting Is Not An Exact Science

Even with all the sophisticated tools, a good forecast is typically supported by the qualitative insights

- . Judgment
- . Experience
- . Intuition




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Features Common to Forecasts

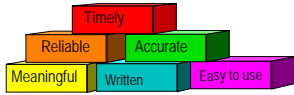
- . Unattended computer forecasts are usually not as good as computer forecasts that incorporate qualitative insights
- . Forecasts are rarely (if ever) correct ... one of the objectives of forecasting is to be the "least" wrong
- . Forecasts are more accurate if developed at the group rather than the item level (Consider a Hanes underwear style with 4 sizes and 6 colors ... the style can be forecasted more accurately than the 24 individual items that make up the style)
- . Forecast accuracy is greatest for periods closer to the time the forecast is developed



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Elements of a Good Forecast

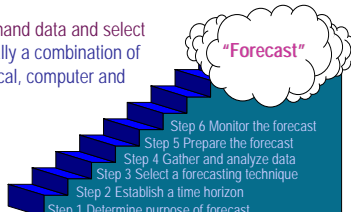
- . A discipline (each time period)
- . Timely
- . Accurate
- . Based on a reliable methodology which is simple to understand and relatively easy to use
- . Published so that all functional areas affected by the forecast can utilize the information (Can you think of an area of an organization that would never have the need for a forecast?)
- . Meaningful so that it can be utilized efficiently and effectively



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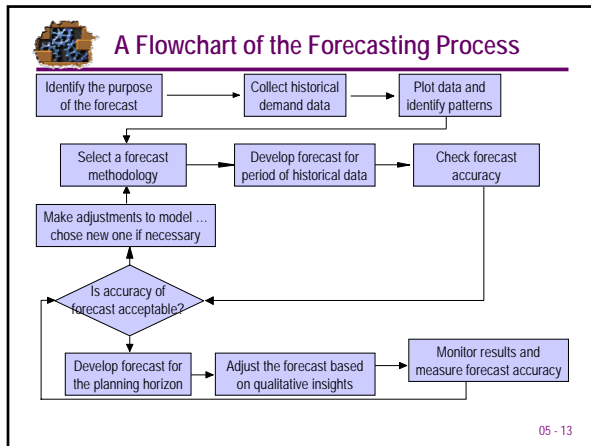
Steps in the Forecasting Process

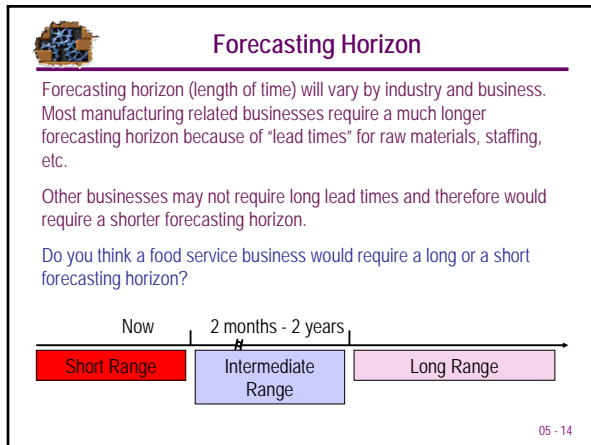
- . Determine the purpose of the forecast (long range planning, new product introduction, day to day operations)
- . Establish a time horizon which the forecast will cover (remember that forecast accuracy diminishes over time)
- . Gather historical demand data and select a methodology (usually a combination of statistical/mathematical, computer and qualitative insight)
- . Prepare the forecast
- . Monitor the forecast

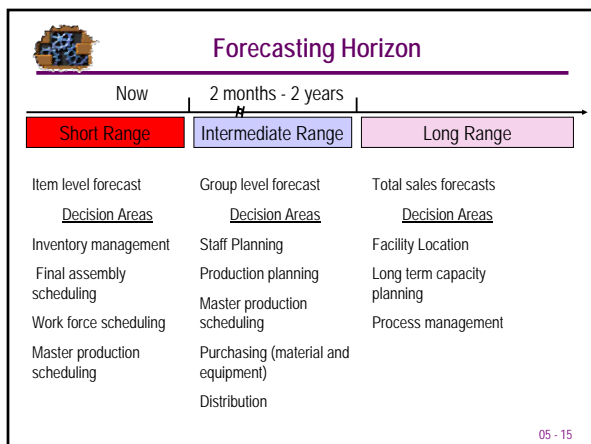


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Forecasting Methodologies

- . *Qualitative* (subjective insights, management, sales and marketing staff etc)
- . *Quantitative* (Mathematical/Statistical Methods)
 - .. *Averaging/Smoothing Techniques*
 - .. *Time Series Techniques*
 - .. *Associative Techniques*

The methodology selected depends

- . on the purpose of the forecast (the quantitative sophistication required usually decreases as the horizon increases)
- . on the amount of data (number of products to be forecasted)

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Qualitative Methodologies


Executive Opinions

Horizon: Long range, new product introduction
Method: High level managers usually meet collectively to develop forecast projections
Risk: Dominant personalities may influence other's input

Direct Customer Contact

Horizon: Intermediate
Method: Sales force input based on contact with customer. The sales force should be knowledgeable about future customer plans (such as promotional events) that could influence demand
Risk: Sales force may not be honest about demand

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Qualitative Methodologies

Customer Surveys

Horizon: Intermediate, long range, new product introduction
Method: Solicit customer input by using a designed survey
Risk: May not get useful or accurate information ... will customer really do what they say

Delphi Method

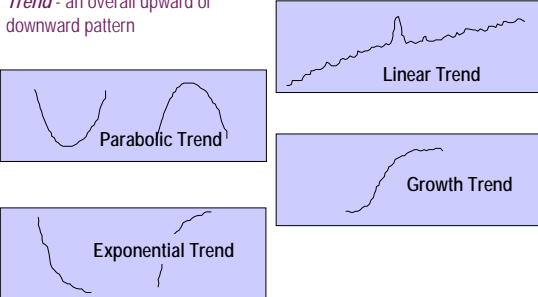
Horizon: Intermediate, long range, new product introduction
Method: A series of anonymous questionnaires where each successive questionnaire builds on the results of the previous one
Risk: Sales force may not be honest about demand

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Demand Variation

Trend - an overall upward or downward pattern



Parabolic Trend

Linear Trend

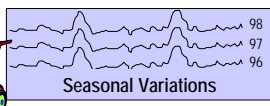
Exponential Trend

Growth Trend

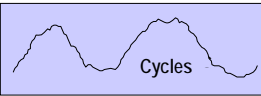
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Demand Variation

Seasonal patterns - regular pattern of up or down depending on time of year (e.g. lawnmower sales)



Seasonal Variations



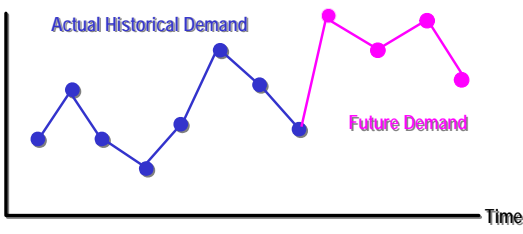
Cycles

Cyclical patterns - repeating up and down movements usually driven by the economy

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History ... An Indicator Of The Future ???

Forecasting deals with making a statement about the future ... Can **history** be used to tell us something about the **future**?




Actual Historical Demand

Future Demand

Time

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Forecast Notation

Time	Actual	Forecast
1	A1	F1
2	A2	F2
3	A3	F3
4	A4	F4
5	A5	F5
6	A6	F6
7	A7	F7
8	A8	F8
9	A9	F9
10	A10	F10

t = time period
 A_t = actual at time t
 F_t = forecast at time t

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Forecast Notation

Time	Actual	Forecast
1	17	#N/A
2	21	#N/A
3	19	#N/A
4	23	19.00
5	18	
6	16	
7	20	
8	18	
9	22	
10	20	

If $t=4$ and $n=3$ what is the forecast for t when using the following forecast methodology?


$$F_t = \frac{A_{t-1} + A_{t-2} + \dots + A_{t-n}}{n}$$

$$= \frac{A_{4-1} + A_{4-2} + A_{4-3}}{3}$$

$$= \frac{A_3 + A_2 + A_1}{3}$$

$$= \frac{17 + 21 + 19}{3} = 19$$

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Forecast Notation

Time	Actual	Forecast
1	17	#N/A
2	21	#N/A
3	19	#N/A
4	23	19.00
5	18	21.00
6	16	20.00
7	20	19.00
8	18	18.00
9	22	18.00
10	20	20.00

Verify these forecasts are correct for the following forecast methodology?

$$F_t = \frac{A_{t-1} + A_{t-2} + \dots + A_{t-n}}{n}$$

Why is the forecast #N/A for $t = 1, 2, 3$?

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Gasoline Sales (000 Gallons)

Period	Actual Demand
1	42
2	40
3	43
4	40
5	41
6	39
7	46
8	44
9	45
10	38
11	40

Actual Demand

What is forecasted demand be for Week 12?

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Templates
Forecasting & Smoothing Methods


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Menu Options
Time Series Forecasting & Smoothing Techniques

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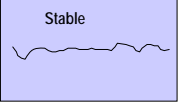
Quantitative Methodologies

Quantitative methods model historical demand variation patterns (random, trend, seasonal or cyclical). Once past history has been explained by a model, extrapolations can be made about the future. Some simplistic techniques are

Averaging/Smoothing Models


- . Naive
- . Moving average
- . Weighted moving average
- . Exponential smoothing

Stable



These techniques are best used when demand is *stable* with no trend or seasonal pattern

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Averaging/Smoothing Models

Naive – next period forecast is the last period actual

Horizon: Short range

Method:


$$N_t = A_{t-1} \text{ where } A_{t-1} = \text{actual at period } t - 1$$

Strength: Low cost, quick and easy to use, simple and easy to understand

Weakness: Not very accurate when a longer forecasting horizon is necessary

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Averaging/Smoothing Models

Weighted moving average of n periods – next period forecast is the weighted average of the previous n periods actual demand

Horizon: Short range
Method:

$$WMA_t = \sum_{i=1}^n A_{t-i} W_{t-i}$$

where A_{t-i} = actual at period $t - i$,
 and W_{t-i} = weighting factor for period $t - i$


Strength: Same as moving average, weights determine influence of previous periods demand
Weakness: Not very accurate when a longer forecasting horizon is necessary, lags actual demand

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Averaging/Smoothing Models

Exponential Smoothing – next period forecast is another weighted average method based on the premise that the most recent period has the highest predictive value.

Horizon: Short range

Method:

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}), \text{ where } F_t = \text{Forecast for period } t,$$

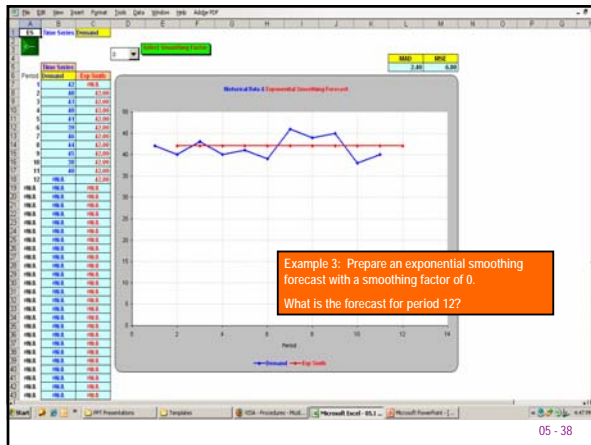
$$F_{t-1} = \text{Forecast for period } t-1, A_{t-1} = \text{actual at period } t-i,$$

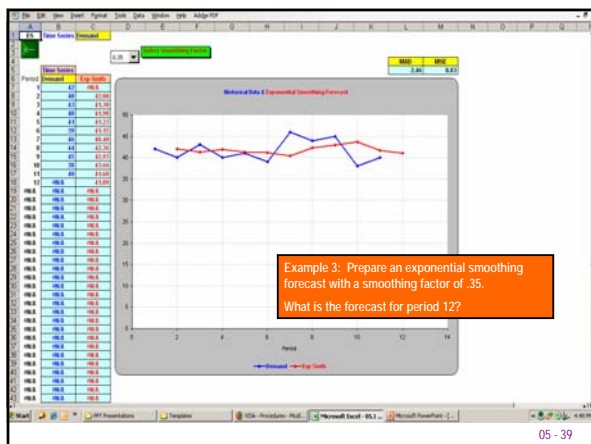
α = smoothing constant (between 0 and 1)

Strength: Same as moving average, smoothing constant can balance the benefits of smoothing with the benefits of responding to real changes

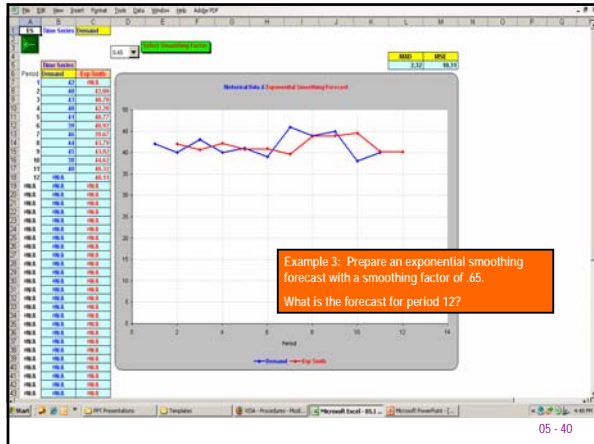
Weakness: Not very accurate when a longer forecasting horizon is necessary, lags actual demand

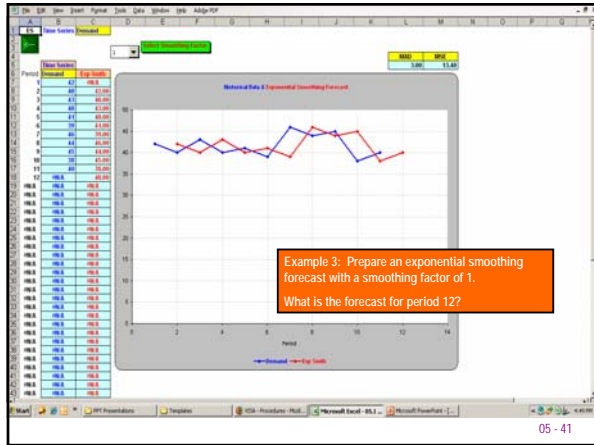
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Exponential Smoothing – Choosing α

Choosing a smoothing constant is basically a matter of judgment and trial and error. The goal is to select a smoothing constant that balances the benefits of smoothing with the benefits of responding to real changes in demand.

The smoothing constant can vary between 0 and 1; however, typically the smoothing constant ranges from .05 to .50. Lower values are used when the historical data shows more stability. Higher values are used when the historical data is more susceptible to change.

When the smoothing constant is 0 the forecast remains constant and is equal to the first actual demand value. When the smoothing constant is 1, the forecast lags actual demand by one period. The next slide shows the forecast for the last example when a smoothing constant of 0 and 1 is chosen.

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Quantitative Methodologies

Time Series Techniques

- . Trends
- . Trend adjusted exponential smoothing
- . Seasonality
- . Cycles
- . Random variations (caused by chance)
- . Irregular variations (caused by unusual circumstances)

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Time Series Example

A company has looked at its quarterly sales over the last three years and believes that a linear trend is present. The data is shown below. Plot the data and determine whether you agree to the company's conjecture.

Let's use this data to examine the linear trend and seasonality methods.

Label	Time	Time Series
Q1	1	14.00
Q2	2	18.00
Q3	3	35.00
Q4	4	46.00
Q1	5	28.00
Q2	6	36.00
Q3	7	60.00
Q4	8	71.00
Q1	9	45.00
Q2	10	54.00
Q3	11	84.00
Q4	12	88.00


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Time Series Techniques

Linear Trend – forecast is projected based on the trend of the historical data

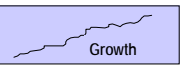
Horizon: Intermediate range
Method:



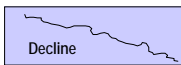
Linear Trend

$F_t = b + mt$ where F_t = Forecast for period t ,
 m = slope of trendline, $b = F_0$

Strength: Ability to determine a linear trend and develop an intermediate range forecast
Weakness: Will not track down turns in the trend



Growth

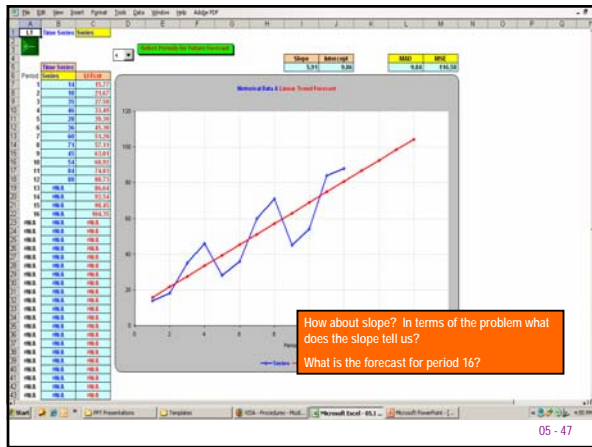



Decline

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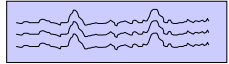




Time Series Techniques

Seasonal Relatives – develops factors based on seasonality. These factors are used to adjust future forecasts

Horizon: Intermediate range

Method: 

Complicated Formula involving moving averages, and centered moving averages. Depends on whether an even or an odd number of periods are in the seasonality.

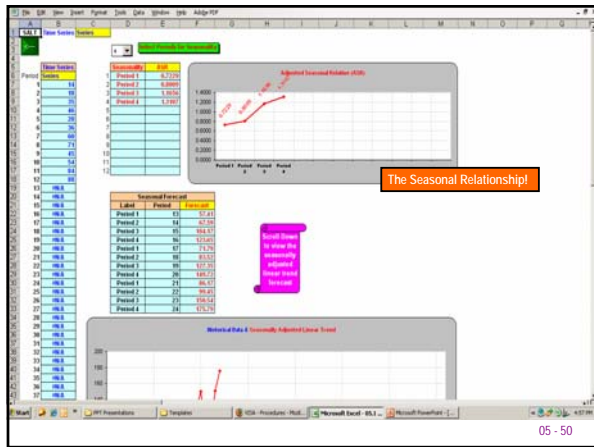
Strength: Ability to determine a seasonality factors to adjust future forecasts.

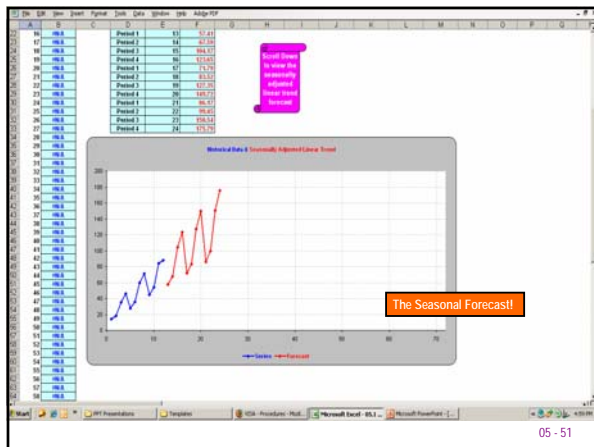
Weakness: Lot of effort when no seasonality exists. Good idea to look at data to determine if seasonality should be considered.

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Quantitative Methodologies

Associative Techniques

- . Simple linear regression
- . Multiple regression
- . Curvilinear regression

Associative means the association or relation between a dependent (Y) variable and one or more independent (X) variables.


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Forecast Accuracy

Given that a forecast is rarely correct, the methodology you choose should be the one which provides the least error from the actual historical demand. **Forecast error** is defined as the difference between actual historical demand and the forecast.

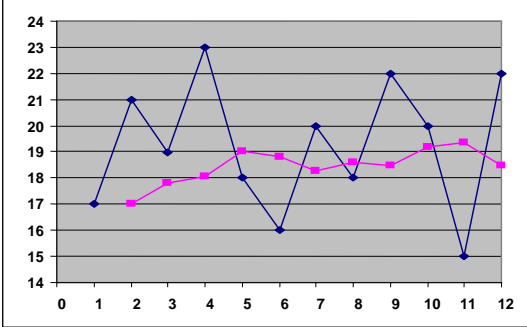
$$\varepsilon_t = \text{Forecast Error} = A_t - F_t$$

where A_t = Actual historical demand at time t
 F_t = Forecast at time t



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Forecast Error



Time (t)	Actual Demand (A _t)	Forecast (F _t)
1	17	17
2	21	17
3	19	18
4	23	18
5	18	19
6	16	19
7	20	18
8	18	19
9	22	18
10	20	19
11	15	19
12	22	18

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Lesson 05 – Forecasting & Smoothing Methods



Monitoring the Forecast

There are two measures used to monitor the accuracy of a forecast. The *Mean Absolute Deviation (MAD)* and the *Mean Squared Error (MSE)*.

The *MAD* is the average of the absolute value of the forecast errors.

The *MSE* is the average of the squared forecast errors.

$$MAD = \text{average } [abs(\epsilon_t)]$$

$$MSE = \text{average } [(\epsilon_t)^2]$$

Note: The formula for the MSE shown above may vary slightly. Some people divide the sum of the squared errors by $n-1$ rather than n .

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Comparing Forecasts

The *MSE* is an estimate of the variation in forecast error.

Therefore, *the forecast methodology which has the least MSE is considered "best"*.

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Controlling the Forecast

The **Forecast Control Chart** monitors the error of a forecast. It is a monitoring approach that sets control limits (multiples of the square root of the MSE) for individual forecast errors. Errors are plotted over time and compared to the control limits to determine the adequacy of the forecast method being used.

We will be discussing **Control Charts** in the Quality Control Chapter. Once familiar with the methodologies, it is a straightforward application of the quality control chart techniques.

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Forecast Control Chart

The **Forecast Control Chart** measures the variability of a forecast errors. The **3-sigma** (99.7%) Forecast Control Chart Centerline, UCL and LCL are calculated by the following formula.


$$\text{Centerline} = 0$$

$$\text{LCL} = -3\sqrt{\text{MSE}}$$

$$\text{UCL} = +3\sqrt{\text{MSE}}$$


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Homework

- Read and understand all material in the chapter.
- Discussion and Review Questions
- Recreate and understand all classroom examples
- Exercises on chapter web page



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