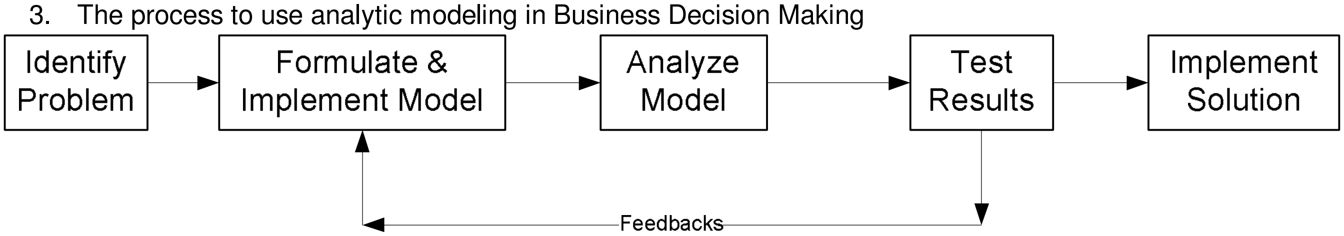
Analytic Modeling Approach to Business Decision Making:

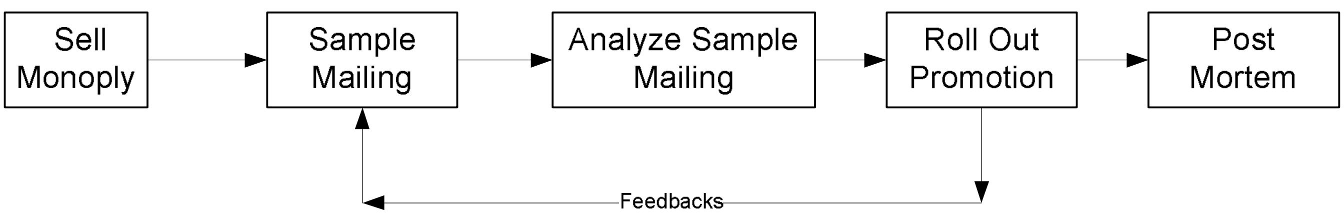
1. Type of general business models
    - Mental model
    - Visual model
    - Prototype or physical or scale model
    - Mathematical models: forecasting, regression, decision, queueing, simulation, LP/ILP models
      Profit = Revenue – Expenses
      Profit=f(Revenue, Expenses)
      $Y = f(X_1, X_2)$
      $Y = f(X_1, X_2, \cdots, X_k)$ where X_i is the variable i in the model for i = 1, 2, …, k

2. Categories of Mathematical Models Figure 1.3 (Ragsdale, pp.6)

	Model Characteristics		
Category	Form of $f(.)$	Values of Independent variables	Management Science Techniques
Prescriptive Models	Known, well-defined	Known or under decision maker's control	LP, Network, ILP, CPM, Goal Programming, EOQ, Nonlinear Programming
Predictive Models	Unknown, ill-defined	Known or under decision maker's control	Regression analysis, Time series analysis, Discriminant analysis
Descriptive Models	Known, well defined	Unknown or uncertain	Queueing, Simulation, PERT, Inventory models

3. The process to use analytic modeling in Business Decision Making





4. Anchoring and Framing Effects
    - Anchor effect: under adjust position relative to Anchor
        - $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$ versus $8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$
    - Framing effect:
        - Sure Win Prospective: Given $1,000 and A1 to receive another $500 or B1 to flip a coin to get $1,000 more if it is head or to get $0 if it is tail.
        - Sure Loss Prospective: Given $2,000 and A2 to give back $500 or B2 to flip a coin to give back $0 if it is head or to give back $1,000 if it is tail.
5. Good Decisions versus Good Outcomes

	Good Outcome	Bad Outcome	
Good Decision	65	5	70
Bad Decision	5	25	30
	70	30	100

P(Good Outcome | Good Decision)=65/70=92.86% P(Bad outcome | Good Decision)=5/70=7.14%
P(Good Outcome | Bad Decision)=5/30=16.67% P(Bad Outcome | Bad Decisioin)=25/30=83.33%

6. Business benefits from analytic modeling
    - Simplicity
    - More economically sound
    - Quick result
    - Examine many things that otherwise could not be possibly be studied
    - Gain insights into business decision making

Forecasting (http://en.wikipedia.org/wiki/Forecasting)

Adam, the manager of customer service department, would like to forecast the number of calls to customer service in order for him to schedule his staff members. The historical data are given in the following table.

The model to be used is: $\hat{Y}_{t+1} = f(Y_t, Y_{t-1}, \cdots, Y_k)$ or the forecast for the period t+1 is the function of the historical data.

How to develop the forecasts? We will use several methods, including: Simple Moving Average (3), Weighted Moving Average (3), and Exponential Smoothing. Regression will be discussed later.

	A	B	C	D	E	F	G	H	I
1	**Class Exercises: Forecasting Methods**								
2	Index	Time	Calls	SMA(3)	WMA(3)	Exp			
3		t	Yt	Y't	Y't	Y't			Weights
4	t-5	1	52					w3	**0.2**
5	t-4	2	73					w2	0.3
6	t-3	3	30					w1	0.5
7	t-2	4	32					sum	1
8	t-1	5	81						
9	t	6	78					α value	0.25
10	t+1	7							
11	t+2	8							
12	t+3	9							
13									
14		MSE =							

How shall the forecasting accuracy of each method be evaluated? We will use Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Mean Squared Error (MSE). The smaller the values of MAE, MAPE and MSE, the better, the forecast.

	A	B	C	D	E	F	G	H
18	Evaluate Forecasting Performance with ME, MAE, MAPE and MSE							
19	Index	Time	Calls	SMA(3)	Error	ABS	APE(%)	ES
20		t	Yt	Y't	(Yt - Y't)	|Yt - Y't|	|(Yt - Y't)/Yt|	(Yt - Y't)^2
21	t-5	1	52					
22	t-4	2	73					
23	t-3	3	30					
24	t-2	4	32	51.667				
25	t-1	5	81	45.000				
26	t	6	78	47.667				
27	t+1	7		63.667				
28	t+2			74.222				
29	t+3							SSE
30		Sum =						
31		Mean =						
32						MAE	MAPE	MSE
33								

The answers to the class exercises are given here.

	A	B	C	D	E	F	G	H	I
1	**Class Exercises: Forecasting Methods**								
2	Index	Time	Calls	SMA(3)	WMA(3)	Exp			
3		t	Y_t	Y'_t	Y'_t	Y'_t			Weights
4	t-5	1	52			52		w3	**0.2**
5	t-4	2	73			52.000		w2	0.3
6	t-3	3	30			57.250		w1	0.5
7	t-2	4	32	51.667	47.300	50.438		sum	1
8	t-1	5	81	45.000	39.600	45.828			
9	t	6	78	47.667	56.100	54.621		α value	0.25
10	t+1	7		63.667	69.700	60.466			
11	t+2	8		79.500	74.450	60.466			
12	t+3	9		78.750	73.735	60.466			
13									
14	MSE=			867.630	809.220	707.858			
15									
16									
17									
18	Evaluate Forecasting Accuracy with ME, MAE, MAPE and MSE								
19	Index	Time	Calls	SMA(3)	Error	ABS	APE(%)	ES	
20		t	Y_t	Y'_t	$(Y_t - Y'_t)$	$\lvert Y_t - Y'_t \rvert$	$\lvert (Y_t - Y'_t)/Y_t \rvert$	$(Y_t - Y'_t)^2$	
21	t-5	1	52						
22	t-4	2	73						
23	t-3	3	30						
24	t-2	4	32	51.67	-19.667	19.667	61.46%	386.778	
25	t-1	5	81	45.00	36.000	36.000	44.44%	1296.000	
26	t	6	78	47.67	30.333	30.333	38.89%	920.111	
27	t+1	7	63.67	63.67					
28	t+2			74.22					
29	t+3							SSE	
30		Sum =			46.667	86.000	1.448	2602.889	
31		Mean =			15.556	28.667	0.483	867.630	
32					ME	MAE	MAPE	MSE	
33								867.630	
34				=SUMXMY2($C$141:$C$143,D141:D143)/COUNT(C141:C143)					

Use Excel@ in developing forecasting models:

1. Use Excel@ formulas: =SUMPRODUCT(), =SUMXMY2(), etc.

2. Use or not use the absolute cell address ($I$111) in Excel@ formulas

3. Excel@ may have more than one way (or formula) to carry out a task (compute WMA or EXP), which one should be used?

4. Use Excel@ Solver or PremSolver to Minimize MSE in order to find the optimal weights for WMA or the optimal smoothing constant for Exponential Smoothing.

Please try out each of the following Excel@ formulas after the class.

138	Use Excel@ formula =SUMXMY2() to get Sum of Squared Error (SSE) for SMA(3) in Time 4 to Time 6:					
139	SMA(3)	SSE =	2602.889	=SUMXMY2(C126:C128,D126:D128)		SSE =
140						
141	Use Excel@ formula =COUNT() to get the number of time periods of forecasts.					
142		n =	3	=COUNT(C126:C128)		n =
143						
144	Use Excel@ formulas =SUMXMY2() and =COUNT() to get MSE for SMA(3) in Time 4 to Time 6:					
145	SMA(3)	MSE =	867.630	=SUMXMY2(C126:C128,D126:D128)/COUNT(C126:C128)		
146						
147	Use Excel@ formula =SUMPRODUCT() to get WMA(3) forecast for Day 4:					
148		WMA(3)4=	47.3	=SUMPRODUCT(C106:C108,$I$106:$I$108)		WMA(3)4=
149						
150	Use Excel@ formulas =SUMXMY2() and =COUNT() to get MSE for EXP in Time 4 to Time 6:					
151	EXP	MSE =	707.858	=SUMXMY2(C109:C111,F109:F111)/COUNT(C109:C111)		
152						MSE =
153	Use Excel@ formulas =SUMXMY2() and =COUNT() to get MSE for WMA(3) in Time 4 to Time 6:					
154	WMA(3)	MSE =	809.220	=SUMXMY2(C109:C111,E109:E111)/COUNT(C109:C111)		
155						MSE=
156	Among SMA(3), WMA(3) and EXP(α=0.2), which method is best suited for the assignment and why?					
157	Min MSE	EXP	707.858	=MIN(C145,C151,C154)	the smallest MSE	

The equations used to develop the answers in Excel@ are given in the following table with Excel@ Formula/Show Formulas option.

	A	B	C	D	E	F	G	H	I
103	**Class Ex**								
104	Index	Time	Calls	SMA(3)	WMA(3)	Exp			
105		t	Y_t	Y'_t	Y'_t	Y'_t			Weights
106	t-5	1	52			=C106		w3	**0.2**
107	t-4	2	73			`=F106+$I$111*(C106-F106)`		w2	0.3
108	t-3	3	30			`=F107+$I$111*(C107-F107)`		w1	0.5
109	t-2	4	32	=AVERAGE(C106:C108)	`=SUMPRODUCT($I$106:$I$108,C106:C108)`	`=F108+$I$111*(C108-F108)`		sum	=SUM(I106:I108)
110	t-1	5	81	=AVERAGE(C107:C109)	`=SUMPRODUCT($I$106:$I$108,C107:C109)`	`=F109+$I$111*(C109-F109)`			
111	t	6	78	=AVERAGE(C108:C110)	`=SUMPRODUCT($I$106:$I$108,C108:C110)`	`=F110+$I$111*(C110-F110)`		α value	0.25
112	t+1	7		=AVERAGE(C109:C111)	`=SUMPRODUCT($I$106:$I$108,C109:C111)`	`=F111+$I$111*(C111-F111)`			
113	t+2	8		=AVERAGE(C110:C112)	=I108*E112+I107*C111+I106*C110	=F112+I111*(F112-F112)			
114	t+3	9		=AVERAGE(C111,C112,D113)	=I108*E113+I107*E112+I106*C111	=F113+#REF!*(F113-F113)			
115									
116	MSE=			`=SUMXMY2($C$109:$C$111,D`	`=SUMXMY2($C$109:$C$111,E109:E111)/CO`	`=SUMXMY2($C$109:$C$111`			
117									
118									
119									
120	Evaluat								
121	Index	Time	Calls	SMA(3)	Error	ABS	APE(%)	ES	
122		t	Y_t	Y'_t	$(Y_t - Y'_t)$	$\|Y_t - Y'_t\|$	$\|(Y_t - Y'_t)/Y_t\|$	$(Y_t - Y'_t)^2$	
123	t-5	1	52						
124	t-4	2	73						
125	t-3	3	30						
126	t-2	4	32	=AVERAGE(C123:C125)	=C126-D126	=ABS(E126)	=ABS(E126/C126)	=E126*E126	
127	t-1	5	81	=AVERAGE(C124:C126)	=C127-D127	=ABS(E127)	=ABS(E127/C127)	=E127*E127	
128	t	6	78	=AVERAGE(C125:C127)	=C128-D128	=ABS(E128)	=ABS(E128/C128)	=E128*E128	
129	t+1	7		=AVERAGE(C126:C128)					
130	t+2								
131	t+3							SSE	
132		Sum =			=SUM(E126:E128)	=SUM(F126:F128)	=SUM(G126:G128)	=SUM(H126:H128)	
133		Mean			=AVERAGE(E126:E128)	=AVERAGE(F126:F128)	=AVERAGE(G126:G128)	=AVERAGE(H126:H128)	
134					ME	MAE	MAPE	MSE	
135								`=SUMXMY2($C$126:$C$128`	
136				`=SUMXMY2($C$141:$C$143,D`					

Topics to be covered:

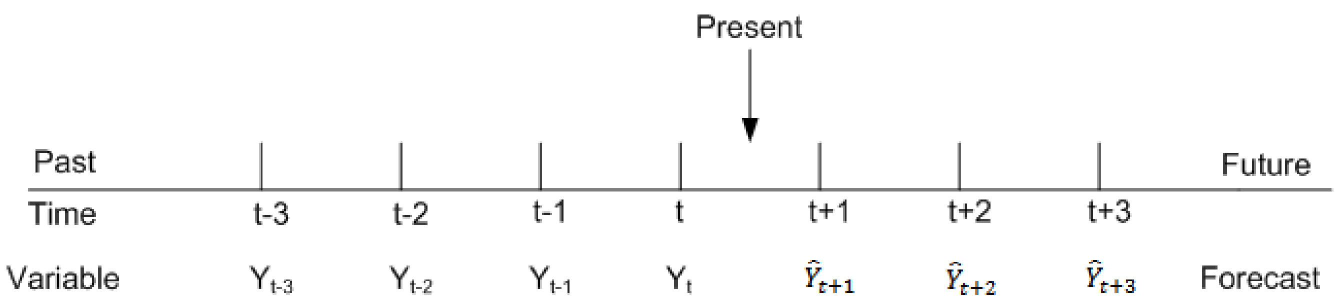
1. Forecasting, qualitative and quantitative forecasting methods
    a. Qualitative forecasting methods: Executive Judgment, Historical analogy, Delphi method, Grass roots, Market research, and Panel consensus.

    b. Quantitative forecasting methods:
        i. Classical Time Series Model $Y = T \bullet C \bullet S \bullet I$ where T, C, S and I refer to the Trend, Cyclical, Seasonal and Irregular component of a time series. Seasonality refers to, any seasonal variations, such as, hourly, daily, weekly, monthly or quarterly effect, that is normally within a year. The Cyclical effect is normally longer than a year, mostly caused by economical cycles and is harder to study.
        ii. Simple Moving Average (SMA) & Naïve Forecast
        iii. Weighted Moving Average (WMA)
        iv. Centered Moving Average and Seasonal Factor
        v. Exponential Smoothing
        vi. Simple Linear Regression (SLR)
        vii. Associative methods:
            ✓ Simple Linear regression
            ✓ Multiple Linear regression
        ii. Combining Forecast

2. Assumptions for quantitative forecasting methods

3. Forecasting Accuracy and Selection of Forecasting Methods

Forecasting Time Line:



Y_t = the actual observation or value of the variable to be forecast for the most recent time period t Prior observations are noted by subtracting 1 from time period t.

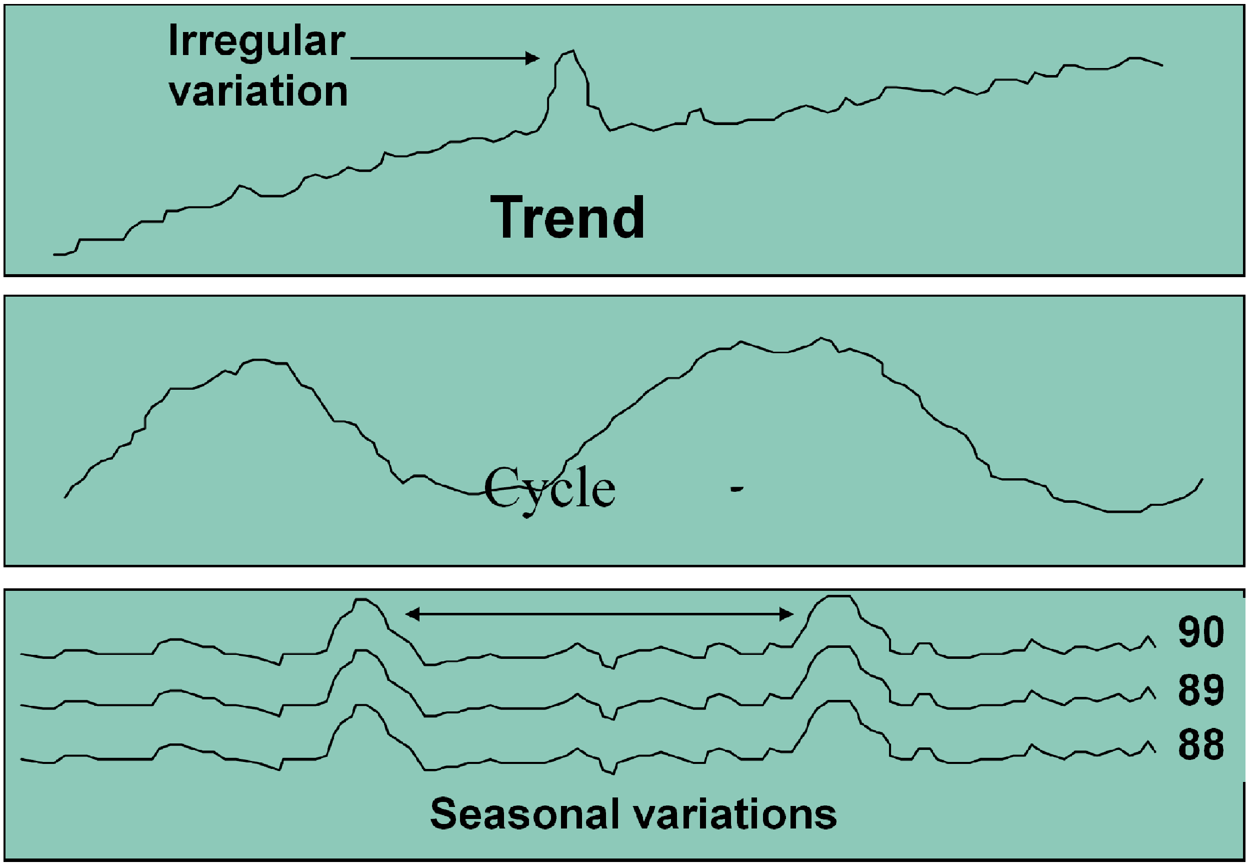
$\hat{Y}_{t+1}$ = the forecasted value for the next period. Following periods are designated by adding 1 to time period t+1.

Forecasting

1. Assumes causal system: past ==> future. The future is going to resemble that of the past.
2. Forecasts rarely perfect because of randomness, What that means "Forecast is always wrong, with 50% over forecast and 50% under forecast" ?
3. Forecasts more accurate for groups (product families, i.e. passenger cars) vs. individuals (i.e. Toyota Camry)
4. Forecast accuracy decreases as time horizon increases

Time Series Forecasts

1. Trend - long-term movement in data
2. Seasonality - short-term regular variations in data
3. Irregular variations - caused by unusual circumstances
4. Random variations - caused by chance



Seasonal Variations

- Regular repeating movements in time series values that can be tied to recurring events
- Annual variations: weather, summer/winter sports equipment
- Vacations/holidays: airline travel, greeting cards, resort
- Daily, Weekly, Monthly: rush traffic hours, theaters and restaurants, banks, mail volume, sales of toys, beer, automobiles, turkeys, highway usage, hotel registrations, gardening, public transportations, electric power plants

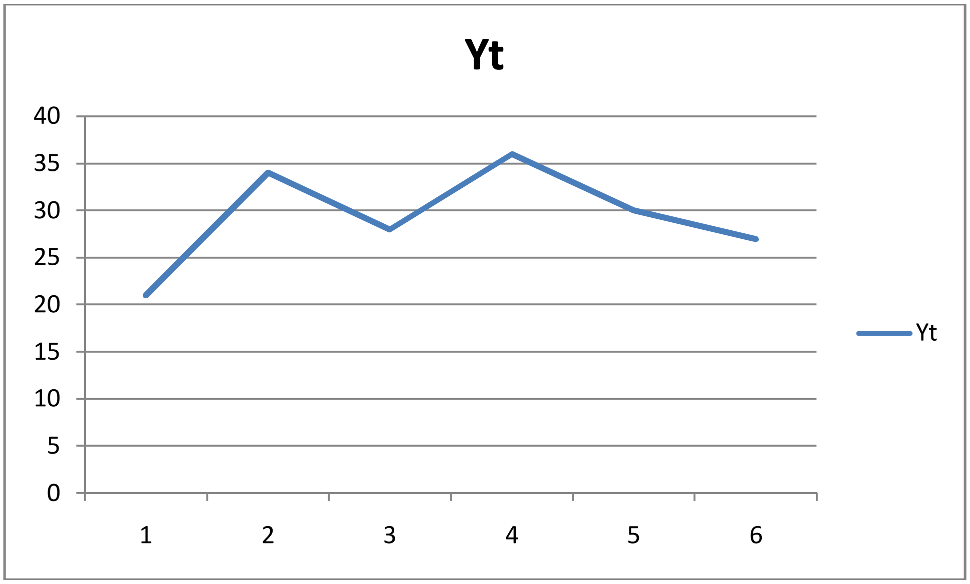
Multiplicative Seasonal Model

- Forecast = Trend x SI x Random Components
- SI = Seasonal Index or Relatives or Percentages
- SI = 1.20 for May, thus Sales in May are 20% above the monthly average
- SI = 0.90 for July, thus Sales in July are only 90% of the monthly average

Forecasting Procedures

- Determine the purpose and time: level of details, resources (manpower, computing times, etc), level of accuracy
- Establish a time horizon
- Select a forecasting technique
- Collect and analyze the data, and prepare the forecast, identify any assumptions
- Monitor the forecast

Example 1, Customer Calls



Mean Error (ME):

$$ME = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)$$

Mean Absolute Error (MAE):

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|Y_i - \hat{Y}_i|$$

Mean Absolute Percentage Error (MAPE):

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{Y_i - \hat{Y}_i}{Y_i}\right|$$

Sum of Squared Error (SSE):

$$SSE = \sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2$$

Mean Squared Error (MSE):

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 = \frac{SSE}{n}$$

Root Mean Squared Error (RMSE): RMSE = $\sqrt{MSE}$

To see Formulas in Excel, click Formulas/Show Formulas

MSE `=SUMXMY2($B$8:$B$10,C8:C10)/COUNT(C8:C10)`

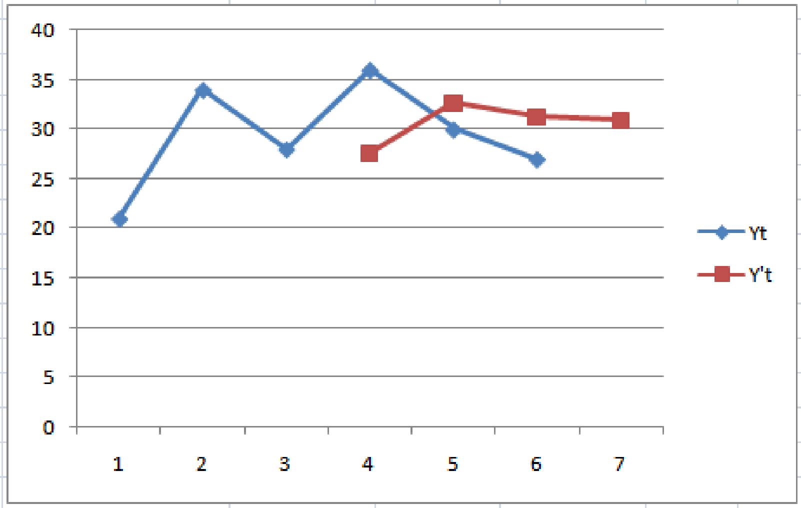
Simple Moving Average: $\hat{Y}_{t+1} = \frac{Y_t+Y_{t-1}+Y_{t-k+1}}{k}$ or $\hat{Y}_4 = \frac{21+34+28}{3} = 27.67$

Forecast more than one period into the future using SMA: some or all of forecasts are used.

Number of Calls Received at Customer Service

Simple Moving Average Forecast (SMA):

Time	Calls	SMA(3)
t	Y_t	Y'_t
1	21	
2	34	
3	28	
4	36	27.667
5	30	32.667
6	27	31.333
7		31.000
8		28.500
9		27.000
MSE =		31.778



	A	B	C
1	Number of Call:		
2	Simple Moving		
3	Time	Calls	SMA(3)
4	t	Y_t	Y'_t
5	1	21	
6	2	34	
7	3	28	
8	4	36	=AVERAGE(B5:B7)
9	5	30	=AVERAGE(B6:B8)
10	6	27	=AVERAGE(B7:B9)
11	7		=AVERAGE(B8:B10)
12	8		=AVERAGE(B9:B11)
13	9		=AVERAGE(B10:B12)
14			
15	MSE =		=SUMXMY2(B8:B10,C8:C10)/COUNT(B8:B10)

MSE = SUMXMY2($B$23:$B$25,C23:C25)/COUNT(C23:C25)

Discussions on Moving Average Method

- n=1, MA=Actual Observation = Naive Forecast
- n>1, MA is more smooth and lag of changes
- as n up, MA is more smooth and not responsive
- n is used to balance costs of responding to data changes versus random variations
- easy to use and understand
- require more data and equal weights for each datum

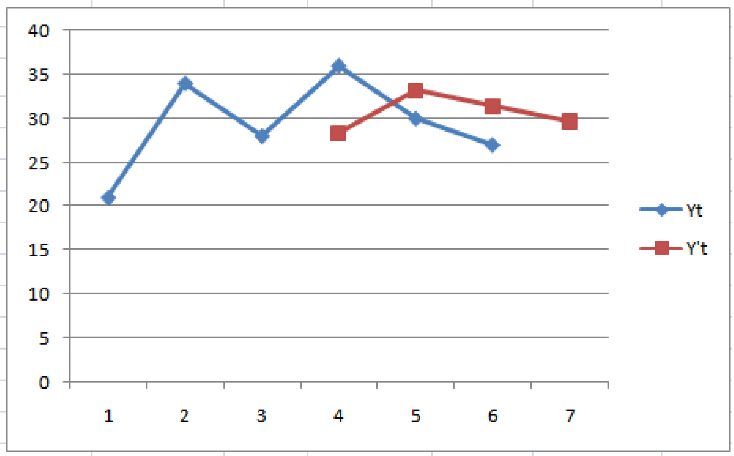
Let us look at the details of SMA forecast again: $\hat{Y}_4 = \frac{21+34+28}{3} = 27.67 = \frac{1}{3}(21) + \frac{1}{3}(34) + \frac{1}{3}(28) = 27.67$
In another word, an equal weight of 1/3 is signed to each of the past observations to get the forecast.
It is often argued that the importance of each of the past observations differs in forecasting future value, thus the use of Weighted Moving Average Forecasting (WMA).

Weighted Moving Average Forecasting (WMA): $\hat{Y}_{t+1} = w1 \times Y_t + w2 \times Y_{t-1} + \cdots + wk \times Y_{t-k+1}$ where k is the number of past observations used in developing the forecast. For a 3 period weighted moving average, k=3.

$$\hat{Y}_4 = 0.5 \times 28 + 0.3 \times 34 + 0.2 \times 21 = 28.40$$

```
=SUMPRODUCT($K$37:$K$39,B37:B39)
=$K$39*B39+$K$38*B38+$K$37*B37
```

	A	B	C	D	E	F
19	Weighted Moving Average Forecast (WMA):					
20	Time	Calls	WMA(3)			
21	t	Y_t	Y'_t			weights
22	1	21		Remote	w3	0.2
23	2	34			w2	0.300
24	3	28		Recent	w1	0.500
25	4	36	28.400		sum	1
26	5	30	33.200			``
27	6	27	31.400		MSE	29.120
28	7		29.700			
29	8		14.100			
30	9		5.400			
31						
32	MSE =		29.120			

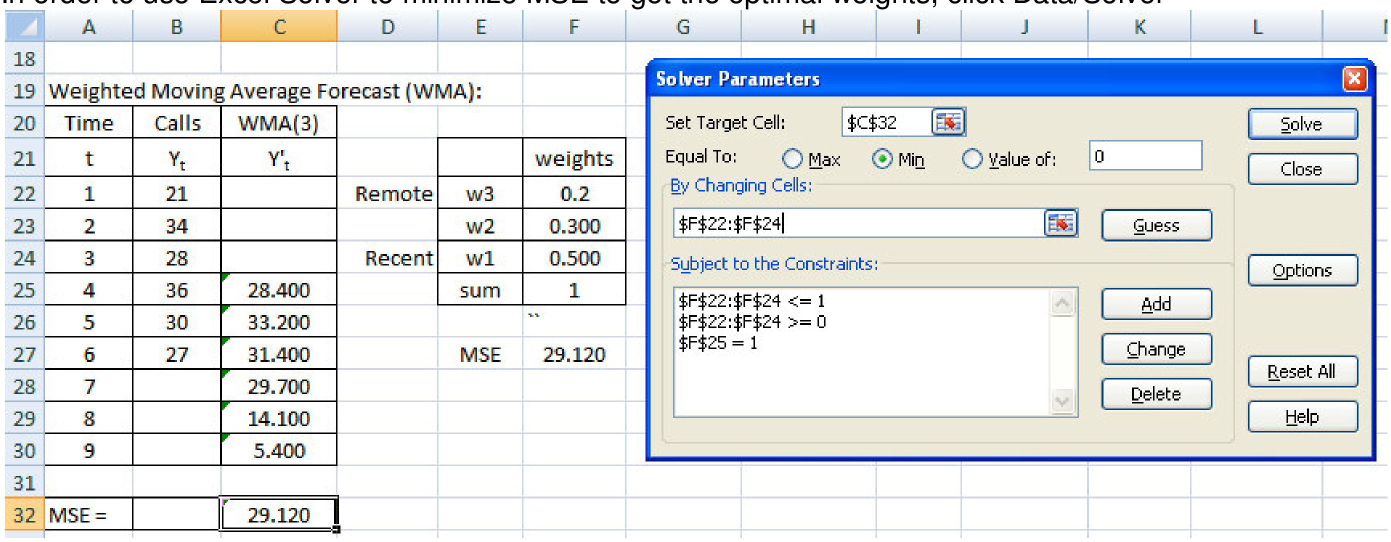


	A	B	C	D	E	F
19	Weighted Mov					
20	Time	Calls	WMA(3)			
21	t	Y_t	Y'_t			weights
22	1	21		Remote	w3	0.2
23	2	34			w2	0.3
24	3	28		Recent	w1	0.5
25	4	36	=SUMPRODUCT($F$22:$F$24,B22:B24)		sum	=SUM(F22:F24)
26	5	30	=SUMPRODUCT($F$22:$F$24,B23:B25)			``
27	6	27	=SUMPRODUCT($F$22:$F$24,B24:B26)		MSE	=SUMXMY2($B$25:$I
28	7		=SUMPRODUCT($F$22:$F$24,B25:B27)			
29	8		=SUMPRODUCT($F$22:$F$24,B26:B28)			
30	9		=SUMPRODUCT($F$22:$F$24,B27:B29)			
31						
32	MSE =		=SUMXMY2(B25:B27,C25:C27)/COUNT(B25:B27)			

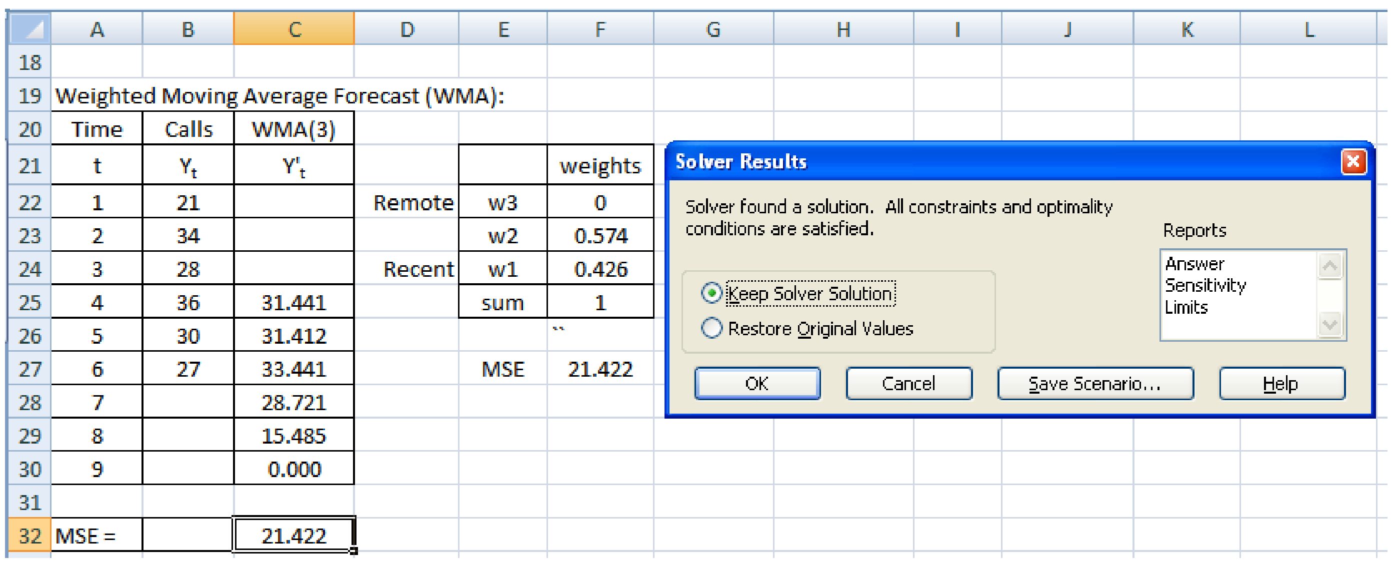
Using Excel@ Solver to optimize weights in WMA forecasting:

Objective function:		Min MSE {=SUMXMY2(B25:B27,C25:C27)/COUNT(B25:B27)}
Constraints:	s.t.	W1, W2, W3 $\geq$ 0
		W1, W2, W3 $\leq$ 1
		W1 + W2 + W3 = 1
Adjust Cells:		F22:F24

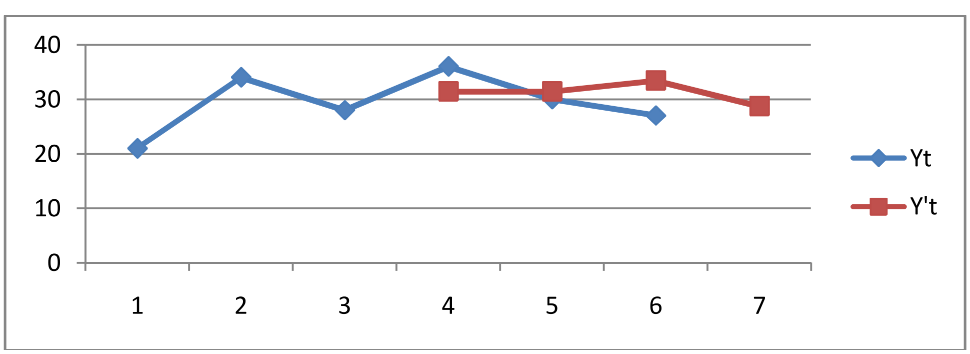
In order to use Excel Solver to minimize MSE to get the optimal weights, click Data/Solver



	A	B	C	D	E	F
18						
19	Weighted Moving Average Forecast (WMA):					
20	Time	Calls	WMA(3)			
21	t	Y_t	Y'_t			weights
22	1	21		Remote	w3	0.2
23	2	34			w2	0.300
24	3	28		Recent	w1	0.500
25	4	36	28.400		sum	1
26	5	30	33.200			
27	6	27	31.400		MSE	29.120
28	7		29.700			
29	8		14.100			
30	9		5.400			
31						
32	MSE =		29.120			



	A	B	C	D	E	F
18						
19	Weighted Moving Average Forecast (WMA):					
20	Time	Calls	WMA(3)			
21	t	Y_t	Y'_t			weights
22	1	21		Remote	w3	0
23	2	34			w2	0.574
24	3	28		Recent	w1	0.426
25	4	36	31.441		sum	1
26	5	30	31.412			
27	6	27	33.441		MSE	21.422
28	7		28.721			
29	8		15.485			
30	9		0.000			
31						
32	MSE =		21.422			



Weighted Moving Average

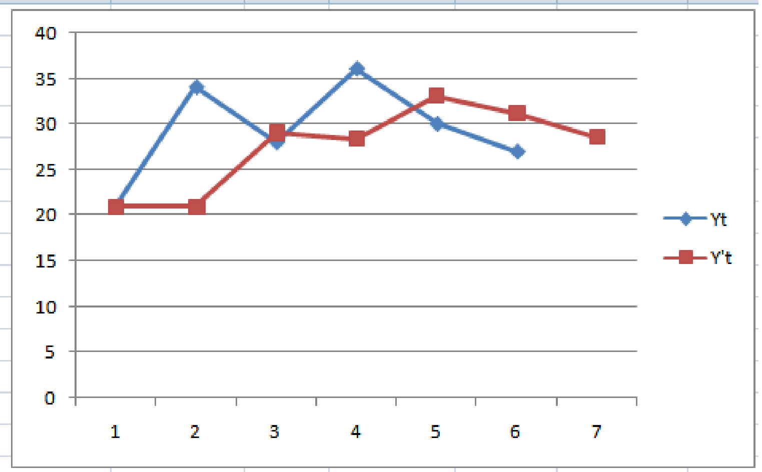
- ✓ MA is a special case of WMA with all of the weights are equal.
- ✓ Choice of weights Ws with Excel Data/Solver is a non linear optimization problem due to MSE
- ✓ Choice of n: may try n = 2, 3, or 4 and use Data/Solver to find the n value with minimum MSE

Forecast more than one period into the future using WMA: some or all of forecasts may be used.

Exponential Smoothing Forecast: $\hat{Y}_{t+1} = \hat{Y}_t + \alpha\big(Y_t - \hat{Y}_t\big) = \alpha(Y_t) + (1-\alpha)\hat{Y}_t = \alpha(Y_t) + \alpha(1-\alpha)Y_{t-1} + \cdots$

=C86+$K$84*(B86-C86)

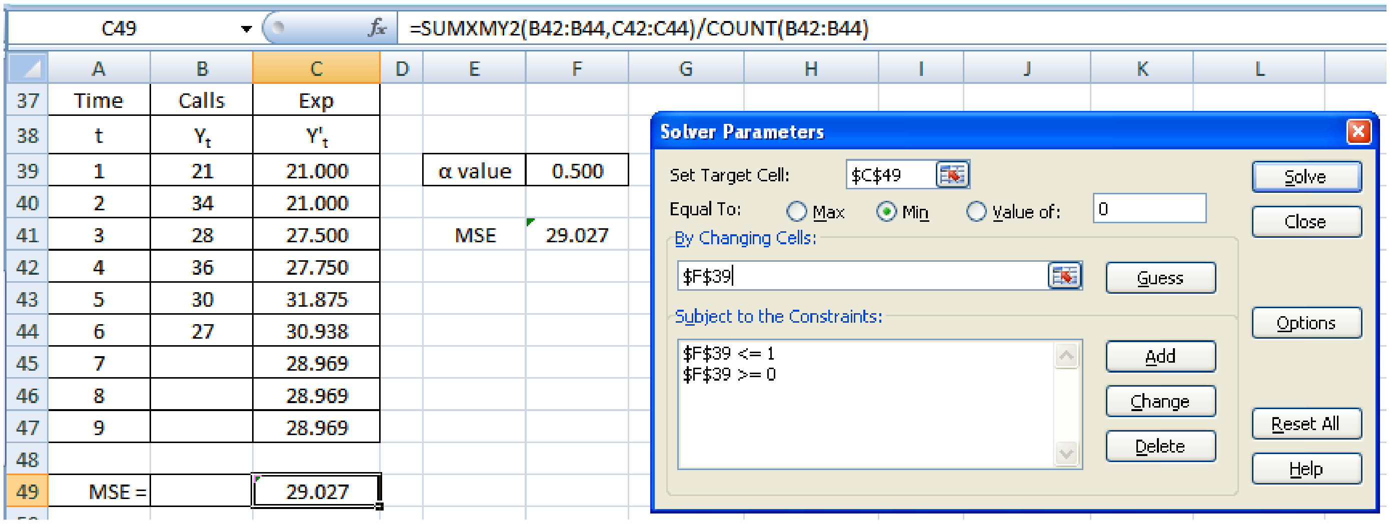
	A	B	C	D	E	F
36	Exponential Smoothing Forecast					
37	Time	Calls	Exp			
38	t	Y_t	Y'_t			
39	1	21	21.000		α value	0.300
40	2	34	21.000			
41	3	28	29.045		MSE	28.302
42	4	36	28.398			
43	5	30	33.102			
44	6	27	31.183			
45	7		28.594			
46	8		10.900			
47	9		4.155			
48						
49	MSE =		28.302			
50						

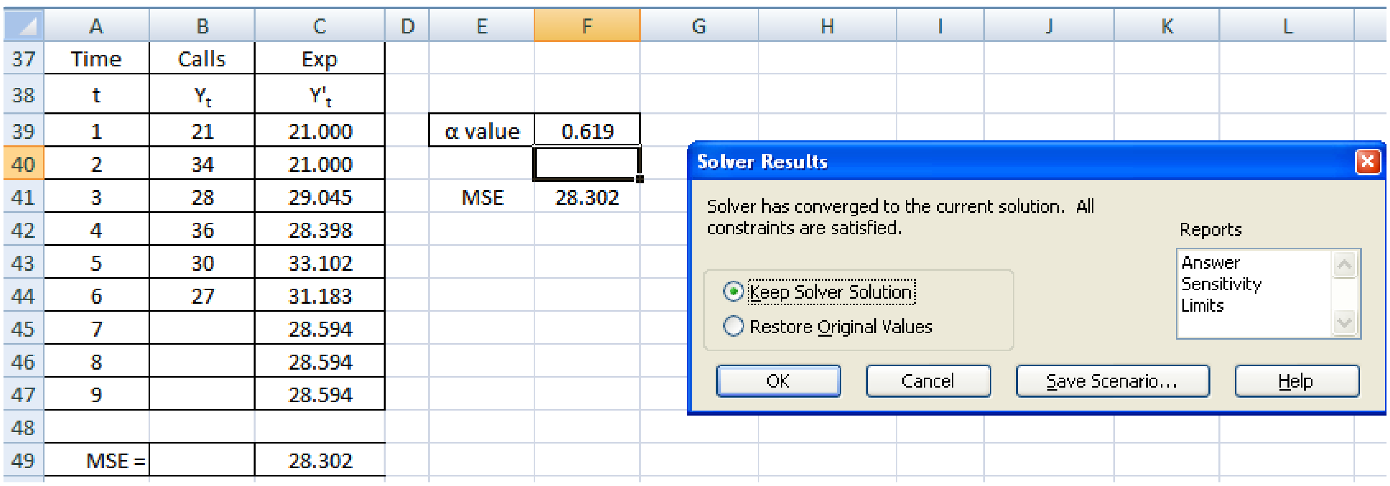


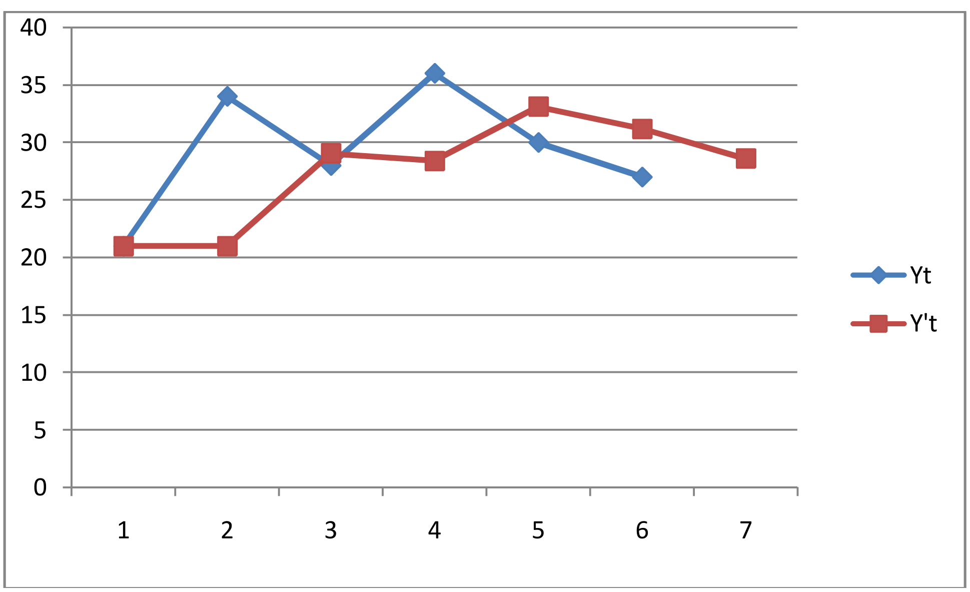
	A	B	C	D	E	F
36	Exponent					
37	Time	Calls	Exp			
38	t	Y_t	Y'_t			
39	1	21	21		α value	0.3
40	2	34	=C39+$F$39*(B39-C39)			
41	3	28	=C40+$F$39*(B40-C40)		MSE	=SUMXMY2(B42:B44,
42	4	36	=C41+$F$39*(B41-C41)			
43	5	30	=C42+$F$39*(B42-C42)			
44	6	27	=C43+$F$39*(B43-C43)			
45	7		=C44+$F$39*(B44-C44)			
46	8		=C45+$F$39*(C45-C45)			
47	9		=C46+$F$39*(C46-C46)			
48						
49	MSE =		=SUMXMY2(B42:B44,C42:C44)/COUNT(B42:B44)			

Using Excel@ Solver to optimize α value in Exponential smoothing forecast:

Objective function: Min MSE {=SUMXMY2(B42:B44,C42:C44)/COUNT(B42:B44)}
Constrarints: s.t. α ≥ 0 and α ≤ 1
Adjust Cells: F39


C49
=SUMXMY2(B42:B44,C42:C44)/COUNT(B42:B44)
Time | Calls | Exp
t | Yt | Y't
1 | 21 | 21.000
2 | 34 | 21.000
3 | 28 | 27.500
4 | 36 | 27.750
5 | 30 | 31.875
6 | 27 | 30.938
7 | | 28.969
8 | | 28.969
9 | | 28.969
MSE = | | 29.027
α value 0.500
MSE 29.027
Solver Parameters
Set Target Cell: $C$49
Equal To: Max Min Value of: 0
By Changing Cells:
$F$39
Subject to the Constraints:
$F$39 <= 1
$F$39 >= 0
Solve
Close
Guess
Options
Add
Change
Delete
Reset All
Help


Time | Calls | Exp
t | Yt | Y't
1 | 21 | 21.000
2 | 34 | 21.000
3 | 28 | 29.045
4 | 36 | 28.398
5 | 30 | 33.102
6 | 27 | 31.183
7 | | 28.594
8 | | 28.594
9 | | 28.594
MSE = | | 28.302
α value 0.619
MSE 28.302
Solver Results
Solver has converged to the current solution. All constraints are satisfied.
Reports
Answer
Sensitivity
Limits
Keep Solver Solution
Restore Original Values
OK
Cancel
Save Scenario...
Help


40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
Yt
Y't

Exponential Smoothing Forecast:

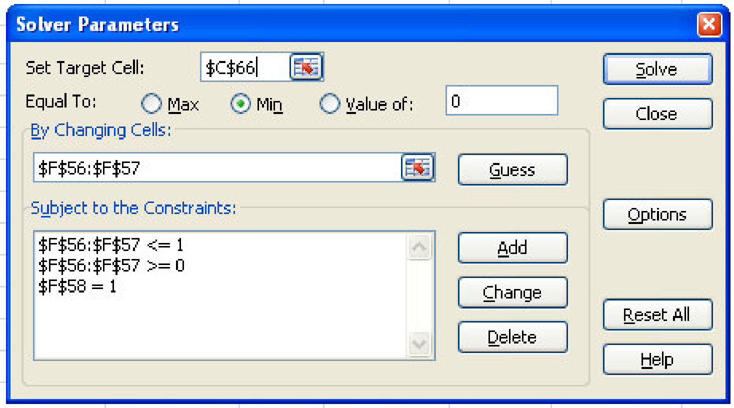
- ✓ Premise--The most recent observations might have the highest predictive value. Therefore, we should give more weight to the more recent time periods when forecasting.
- ✓ Strengths
- ✓ Weaknesses
- ✓ WMA is a special case of Exponential smoothing. When α = 1, Exponential Smoothing leads to Naïve forecasting.

Another way to set up Exponential Smoothing Forecast in Exc

=$K$67*B69+$K$68*C69

C66 =SUMXMY2(B59:B61,C59:C61)/COUNT(B59:B61)

	A	B	C	D	E	F
53	Exponential Smoothing Forecast					
54	Time	Calls	Exp			
55	t	Y_t	Y'_t		Weights	
56	1	21	21.000	Yt	α	0.400
57	2	34	21.000	Y't	1− α	0.600
58	3	28	26.200		sum	1
59	4	36	26.920			
60	5	30	30.552		MSE	31.283
61	6	27	30.331			
62	7		28.999			
63	8		28.999			
64	9		28.999			
65						
66	MSE =		31.283			



	A	B	C	D	E	F
53	Exponer					
54	Time	Calls	Exp			
55	t	Y_t	Y'_t		Weights	
56	1	21	21	Yt	α	0.4
57	2	34	=$F$56*B56+$F$57*C56	Y't	1− α	0.6
58	3	28	=$F$56*B57+$F$57*C57		sum	=SUM(F56:F57)
59	4	36	=$F$56*B58+$F$57*C58			
60	5	30	=$F$56*B59+$F$57*C59		MSE	=SUMXMY2(B59:B61,
61	6	27	=$F$56*B60+$F$57*C60			
62	7		=$F$56*B61+$F$57*C61			
63	8		=$F$56*C62+$F$57*C62			
64	9		=$F$56*C63+$F$57*C63			
65						
66	MSE =		=SUMXMY2(B59:B61,C59:C61)/COUNT(B59:B61)			

Summary of Forecasts for Customer Calls data

Time	Calls	SMA(3)	WMA(3)	Exp
t	Y_t	Y'_t	Y'_t	Y'_t
1	21			21
2	34			21
3	28			29.045
4	36	27.667	31.441	28.398
5	30	32.667	31.412	33.102
6	27	31.333	33.441	31.183
7		31.000	28.721	28.594
8		29.333	27.734	28.594
9		29.111	28.300	28.594
MSE =		31.778	21.422	28.302

	weights
w3	0
w2	0.574
w1	0.426
sum	1

α value	0.619

Exponential Smoothing Forecast

Time	Calls	Exp	Error	ABS	APE(%)	ES
t	Y_t	Y'_t	$(Y_t - Y'_t)$	$\|Y_t - Y'_t\|$	$(Y_t - Y'_t)/Y_t$	$(Y_t - Y'_t)^2$
1	21	21				
2	34	21.00				
3	28	29.04				
4	36	28.398	7.602	7.602	0.211	57.787
5	30	33.102	-3.102	3.102	0.103	9.624
6	27	31.183	-4.183	4.183	0.155	17.494
7		28.594				
8		10.900				
9		4.155				SSE
Sum =			0.317	14.887	0.469	84.906
Mean =			0.106	4.962	0.156	28.302
				MAE	MAPE	MSE
						28.302

α	0.6188
MSE	28.302

Picking a Smoothing Constant α with Excel Data/Solver

Discussions on Exponential Smoothing

- ✓ α - positively related to responsiveness
- ✓ α -(0.05-0.50) and trial and error
- ✓ easy to calculate and need minimum of data
- ✓ widely used
- ✓ α up - more weight on recent obs
- ✓ not useful if trend exists

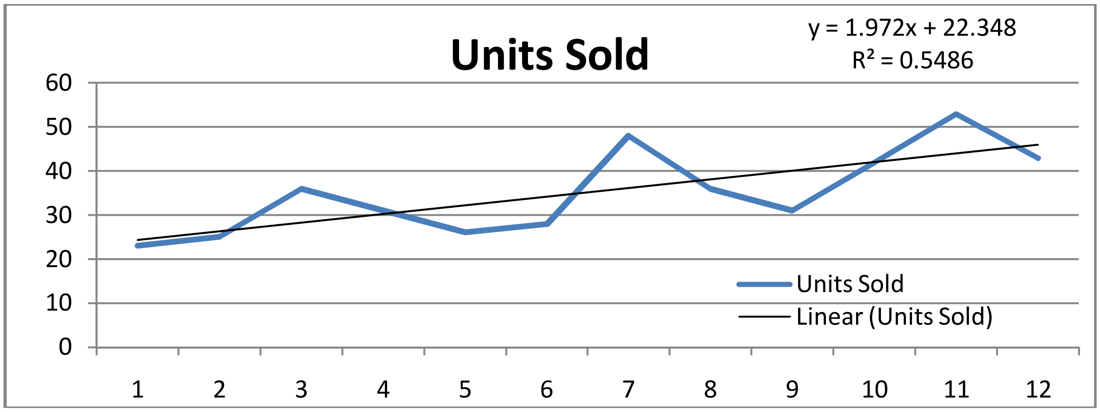
How to develop a forecast if the data has Trend, Seasonality and Random components?

Here is the SUV Sales data from Ragsdale 5th Edition.

Year	Quarter	Time	Units Sold
2003	1	1	**23**
	2	2	**25**
	3	3	**36**
	4	4	**31**
2004	1	5	**26**
	2	6	**28**
	3	7	**48**
	4	8	**36**
2005	1	9	**31**
	2	10	**42**
	3	11	**53**
	4	12	**43**
2006	1	13	--
	2	14	--
	3	15	--
	4	16	--

Given the data for Number of SUV sold, develop forecst for 2006

1. Use Excel@ Insert/Line Chart to draw the data. It appears the data has trend and quarterly seasonality
2. Use Excel Data/Data Analysis/Regression to find values for the b0 and b1, the regression line, and R Square value.
3. Use Hypothesis Test to test β0 and β1 to be sure they are not zeros, i.e. p-value for each is very small < 0.05
4. Use the model Y = T. C. S. I = Trend.Cycle.Season.Irregular
5. Use Excel =Intercept() and =Slope () as below to get the B0 and B1 for the Regression Line Trend, i.e. 1.972 x + 22.34 = Y
6. S.I Relative = Units Sold (Y) / Trend, i.e. 23/24.321 = 0.946
7. Create a table with S.I Relatives in the same quarter lined up together as in the Table
8. Use =Average () to get the average of the S.I Relatives for each quarter and sum up the four S.I Relatives to 4.001, i.e. =average() = 0.8420 for the first quarter
9. Use each quarter S.I Relative divides 4.001 and times 4.000 as adjustment, i.e. 0.8420/4.001*4.000=0.8418 as SI Index
10. Create a column SI Index, and use the same SI Index for the same quarter of each year, i.e. 0.8418 for first quarter of each year
11. Use Trend * SI Index to get the Seasonally Adjusted Fcst (Y'), i.e. 24.321 * 0.8418 = 20.473 for 2003.1 Quarter
12. Use Excel to plot Fcst (Y') and Units Sold to show how well the forecast is to be



SUMMARY OUTPUT

Quarter

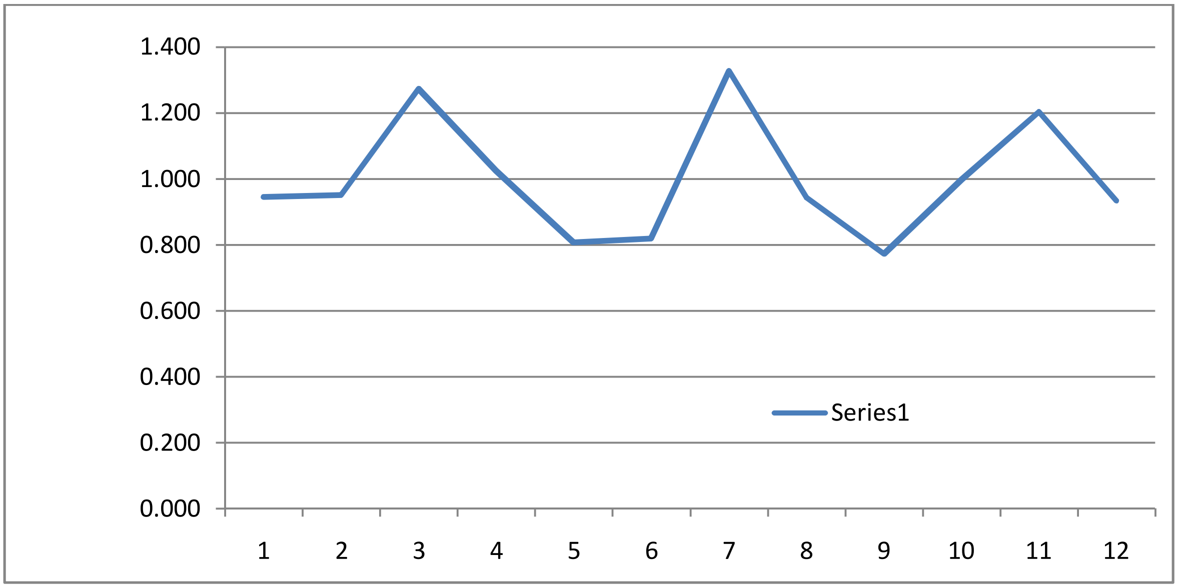
Regression Statistics	
Multiple R	0.7407
R Square	0.5486
Adjusted R Square	0.5035
Standard Error	6.7643
Obs	12

	1	2	3	4	
2003	0.946	0.951	1.274	1.025	
2004	0.807	0.819	1.328	0.944	
2005	0.773	0.998	1.203	0.935	
Average	0.8420	0.9228	1.2683	0.9680	4.001
	0.8418	0.9225	1.2679	0.9677	4.0000
					4

ANOVA

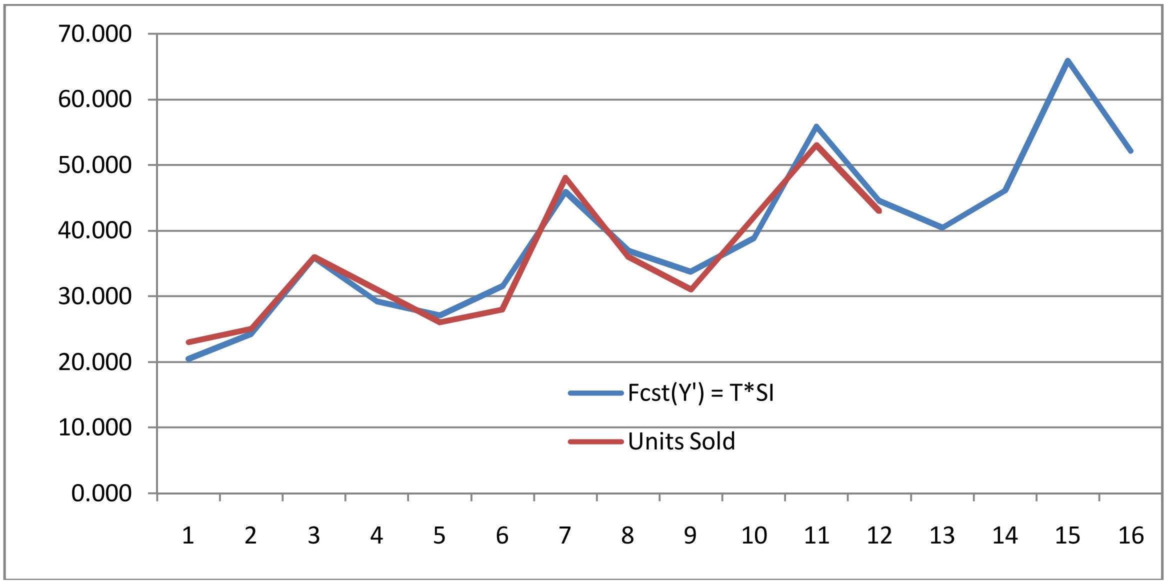
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	556.1119	556.1119	12.1540	0.0059
Residual	10	457.5548	45.7555		
Total	11	1013.6667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	22.348	4.163	5.368	0.000	13.072	31.625	13.072	31.625
Time	1.972	0.566	3.486	0.006	0.712	3.232	0.712	3.232



Year	Quarter	Time	Units Sold	T Trend	DeTrend S.I =Y/(T.C) S.I Comp	SI Index	Fcst(Y') = T*SI
2003	1	1	**23**	24.321	0.946	0.8418	20.473
	2	2	**25**	26.293	0.951	0.9225	24.256
	3	3	**36**	28.265	1.274	1.2679	35.837
	4	4	**31**	30.237	1.025	0.9677	29.261
2004	1	5	**26**	32.209	0.807	0.8418	27.113
	2	6	**28**	34.181	0.819	0.9225	31.533
	3	7	**48**	36.153	1.328	1.2679	45.839
	4	8	**36**	38.125	0.944	0.9677	36.895
2005	1	9	**31**	40.097	0.773	0.8418	33.753
	2	10	**42**	42.069	0.998	0.9225	38.810
	3	11	**53**	44.041	1.203	1.2679	55.840
	4	12	**43**	46.013	0.935	0.9677	44.529
2006	1	13	--	47.985		0.8418	40.393
	2	14	--	49.957		0.9225	46.087
	3	15	--	51.929		1.2679	65.842
	4	16	--	53.901		0.9677	52.162

Intercept =	22.348
Slope =	1.972



Combining Forecast with varying weights

Summary of Forecast:

- Limitations of forecasting capabilities
  - It is more of art than science
  - Combining forecast generates improved performance
- None of the criterion to evaluate forecasting accuracy performs better than others – you make your choice based upon your personal preference and industry practice
- Quantitative forecasting methods show to outperform qualitative methods over time.
- Be aware of the possible mistakes in using Excel and the potential damage from the mistakes.