Business Forecasting in Real Problems

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Forecasting

- The use of forecasting is wide and it has a long history
- Ancient years (Delfi, Incas)
- Astrology, Future Tellers
- Sciences: e.g. Metereology, Physics
- Finance: e.g. Stock Market
- In Real Life: Economic Crisis

Prediction is very difficult, especially if it is about the FUTURE

Niels Bohr, Received Nobel Prize in Physics (1922)

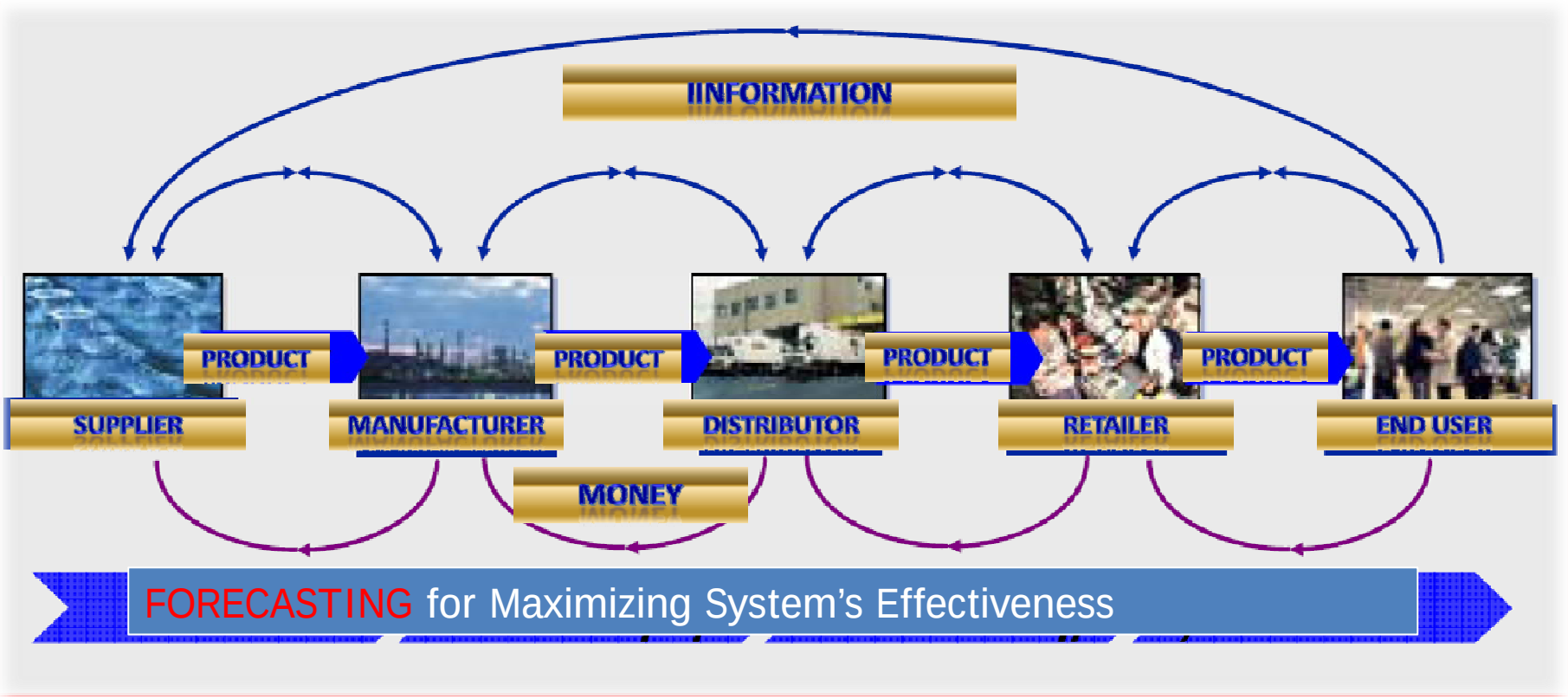
Business Fields of Interest

In business, forecasting can be used in all management levels.

Crucial role in scheduling raw materials, human resources, operations etc.

- ✓ Accounting : Cost / profit estimates
- ✓ Finance: Funding and cash flows
- ✓ Marketing: Promotion strategy, pricing strategy
- ✓ Operations: Schedules, workloads
- ✓ Human Resources (HR): Training needs, location of resources, hiring recruiting needs
- ✓ Research and Development: New product/service design

The Role of Forecasting



Forecast Characteristics (1/3)

- ✓ **Forecasts are not usually wrong, they are ALWAYS WRONG!!!**
  - Flexibility is the only solution to this problem
- ✓ **A good forecast is usually more than a single number**
  - Extra information is given, e.g. error, value range (40±5 items)
- ✓ **The longer the forecasting horizon, the less accurate the forecasts will be**
  - Is it safer to forecast the demand of products for tomorrow or for the same day after one year?
  - The answer is simple: FOR TOMORROW

Forecast Characteristics (2/3)

- ✓ **Aggregate forecasts are more accurate (more products)**

Product A:	AD=5,	F=4,	E= 1/5 (20%)
Product B:	AD=5,	F=5,	E= 0 /0 (0%)
Product C:	AD=5,	F=4,	E= 1 /5 (20%)
Product D:	AD=5,	F=6,	E= -1/5 (20%)

where AD: Actual Demand, F: Forecast and E: Error

Total	AD=20	F=19	E=1/20 (5%)

The 6 Elements of Precise Forecasting

Should be TIMELY

Should be ACCURATE

Should be RELIABLE

Should be in MEANINGFUL UNITS

Should be presented in WRITTING

Should be EASE TO USE

Forecasting Horizon (1/3)

✓ *Short term* (days or weeks)

- Inventory management
- Orders execution
- Production and material planning (MRP)
- Work shifts

Operational Level

Forecasting Horizon (2/3)

✓ *Intermediate term* (weeks or months)

- Inventory levels
- Sales patterns for product families
- Requirements and abilities of employees
- Resources requirements

Tactical level

Forecasting Horizon (3/3)

✓ *Long term* (months or years)

- Long term planning of capacity needs
- Needs in new technologies
- Search for new markets
- Search for new alliances

Strategic level

Forecast Systems (1/3)

Forecast System: a number of methods and techniques employed for collecting, processing and analyzing input data in order to come up with the right conclusions (output data)

Forecast Systems (2/3)

Input Data

Internal Sources of Information:

- Historic data (e.g. demand of raw materials, sales).
- Executive opinions
- Market surveys

External Sources of Information:

- Consulting firms
- Research institutes
- Public bodies

Forecast Systems (3/3)

Output Data

Resulting data according to the company's needs and management level,

For example:

- Production Department (demand)
- Marketing Department (income, age)
- HR Department (available resources, training programs)

Forecasting Methods

- ✓ Qualitative Methods *(relied on opinion and intuition)*
  - Jury of executive opinion
  - Sales force composite
  - Consumer surveys
  - The Delphi method

- ✓ Quantitative methods *(use of mathematical models and historical data)*
  - Casual methods
  - Time series methods

Qualitative Methods (1/3)

- ✓ Qualitative Methods *(relied on opinion and intuition)*
  - Useful in case:
    - There is not enough data
    - There is time limit to develop quantitative methods
  - Often used in practice
  - More appropriate for long term forecasts

Qualitative Methods (2/3)

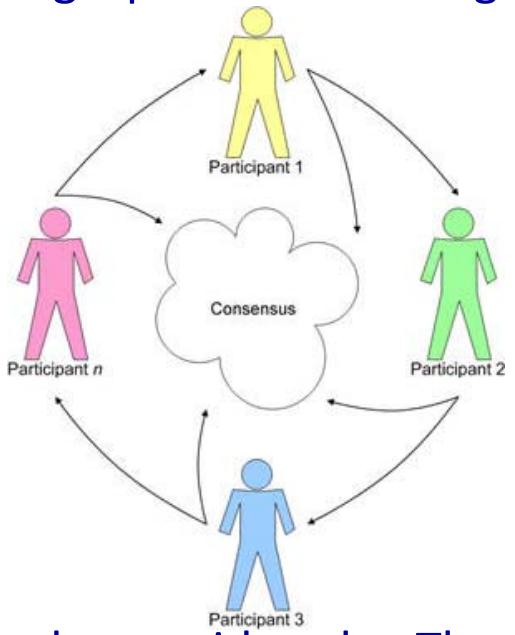
- ✓ Sales force composite
  - Feedback from customers
  - More effective in aggregation of sales personnel estimates
- ✓ Consumer surveys
  - Obtain data regarding future trends
  - The key of success: Carefully designed questionnaires and selected samples
- ✓ Jury of executive opinion
  - In case of lack of historic evidence e.g. new product, it is safer to ask an expert

Qualitative Methods (3/3)

✓ Delphi Technique

A method to obtain a consensus forecast by using opinions from a group of "experts"

- expert opinion
- consulting salespersons



How Delphi Technique works?

- Individual opinions are compiled and considered. These are anonymously shared among group. Then opinion request is repeated until an overall group consensus is (hopefully) reached.

Quantitative Methods (1/3)

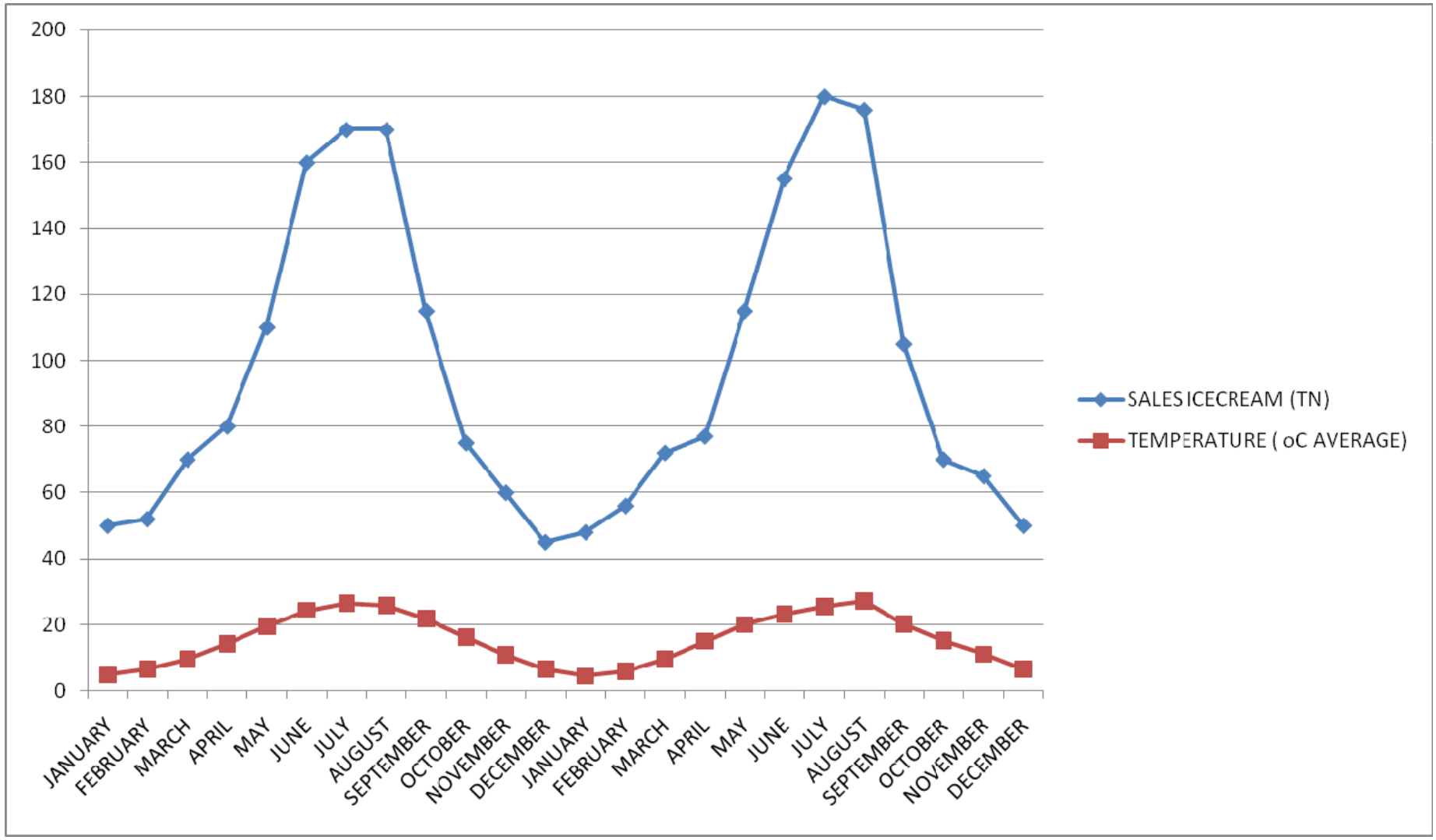
- ✓ *Casual Models*
  - Use the relationship between demand and some other factor to develop forecast
- ✓ *Time Series Methods*
  - Use of historical data only
  - Two types of methods: stationary and non stationary time-series
- ✓ *Basic Assumptions for the Use of Quantitative Methods*
  - "Stable" business environment
  - Future demand will be close to past demand

Quantitative Methods (2/3)

✓ *Simple Steps to Build Models*

- Collect data
- Plot data over time (use of charts in Excel)
- Check for possible cause/effect relationships
- Check for possible patterns (e.g. seasonality, trends etc)
- Reduce/clean data (remove outliers) –*if it is applicable*
- Built forecast model
- Evaluate the model's accuracy and keep track of model's accuracy over time (redo if needed)

Quantitative Methods (3/3)



Can you recognize any possible relationships or patterns?

Casual Models

✓ *Casual Models*

- Relationship between **Y** (phenomenon that is to be forecasted) and $\mathbf{X_n}$ (*n* variables that are related to the phenomenon)
- Econometric models are causal models in which the relationship between **Y** and (**X1 , X2 , . .., $\mathbf{X_n}$**) is linear:

$$\mathbf{Y = a_o + a_1 X_1 + a_2 X_2 + \ldots + a_n X_n}$$

where $\mathbf{a_1 , a_2 , . . . , a_n}$ are constants

- For example

Y= 300 -1000 $\mathbf{X_1}$, where:

Y= Sales of apartments

$\mathbf{X_1}$ = Interest rate

If $\mathbf{X_1}$= 10% (0,1) then **Y**=200

If $\mathbf{X_1}$= 5% (0,05) then **Y**=250

Time Series Methods (1/5)

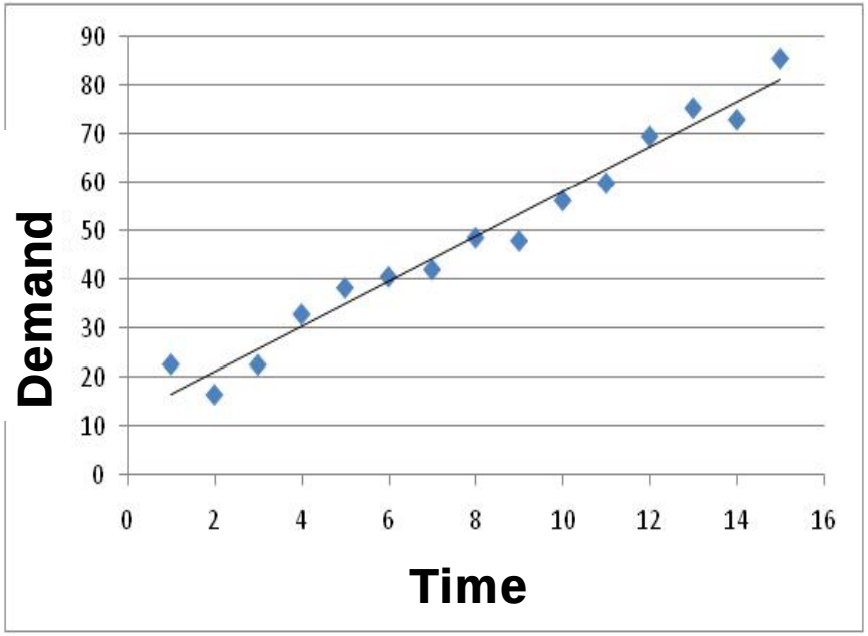
✓ *Time Series Patterns that arise most often:*

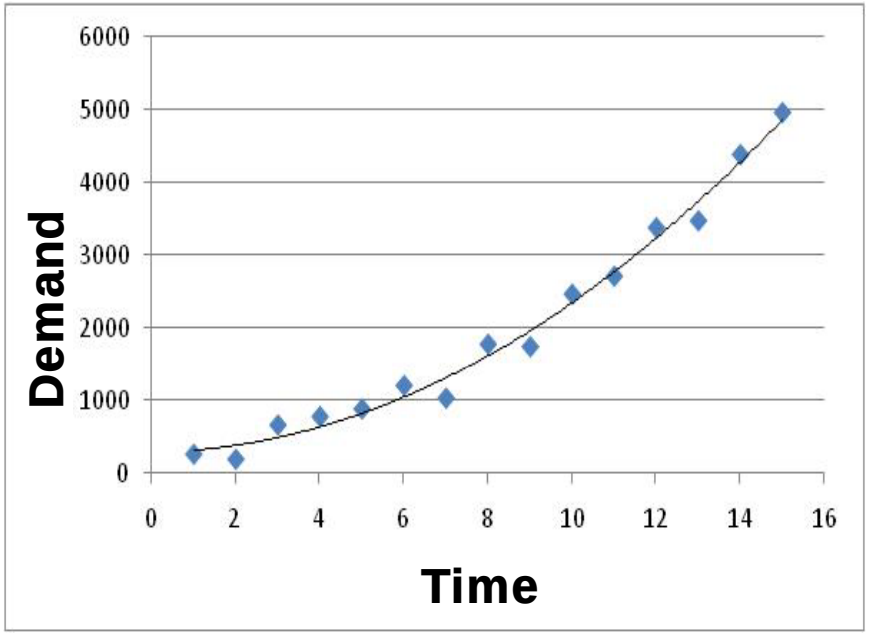
- **Trend:** Long-term movement in data
- **Seasonality:** Short-term regular variations in data
- **Cycles:** Wavelike long-term (more than one year duration) variation in data
- **Random Variations - Stochasticity:** Caused by chance

Time Series Methods (2/5)

✓ *Trend:*

- **Constant increase or decrease of values (linear or nor linear)**

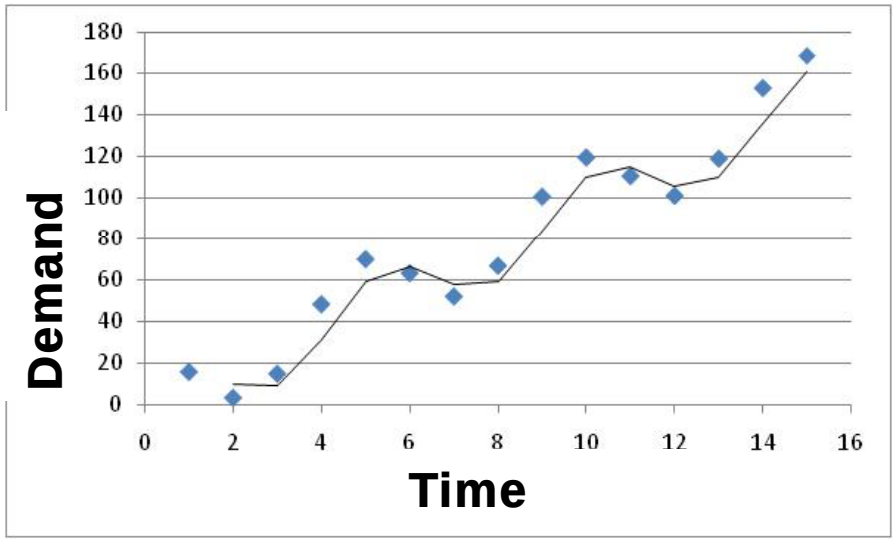


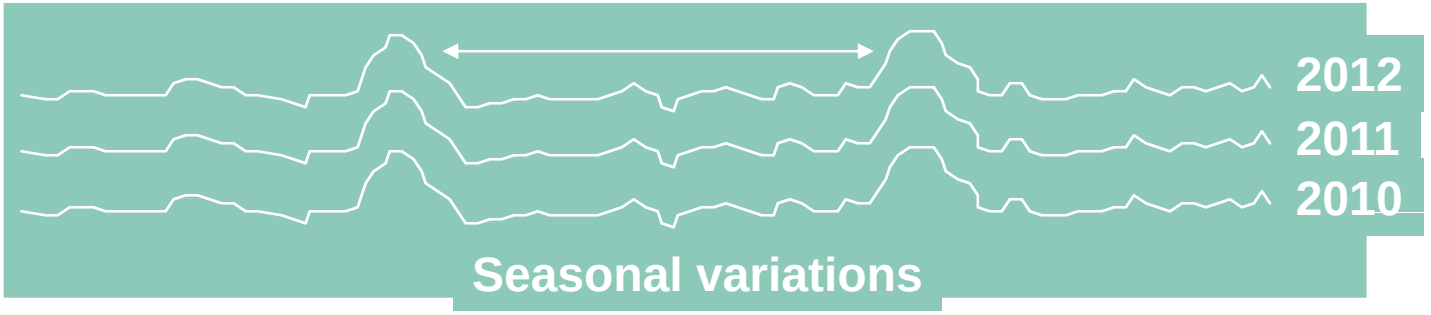


Time Series Methods (3/5)

✓ *Seasonality:*

- **Repeat of values in fixed time periods (e.g. weeks, months)**
- **Examples: Fashion, Icecreams, Heating Oil, Gas, Electricity Power etc**

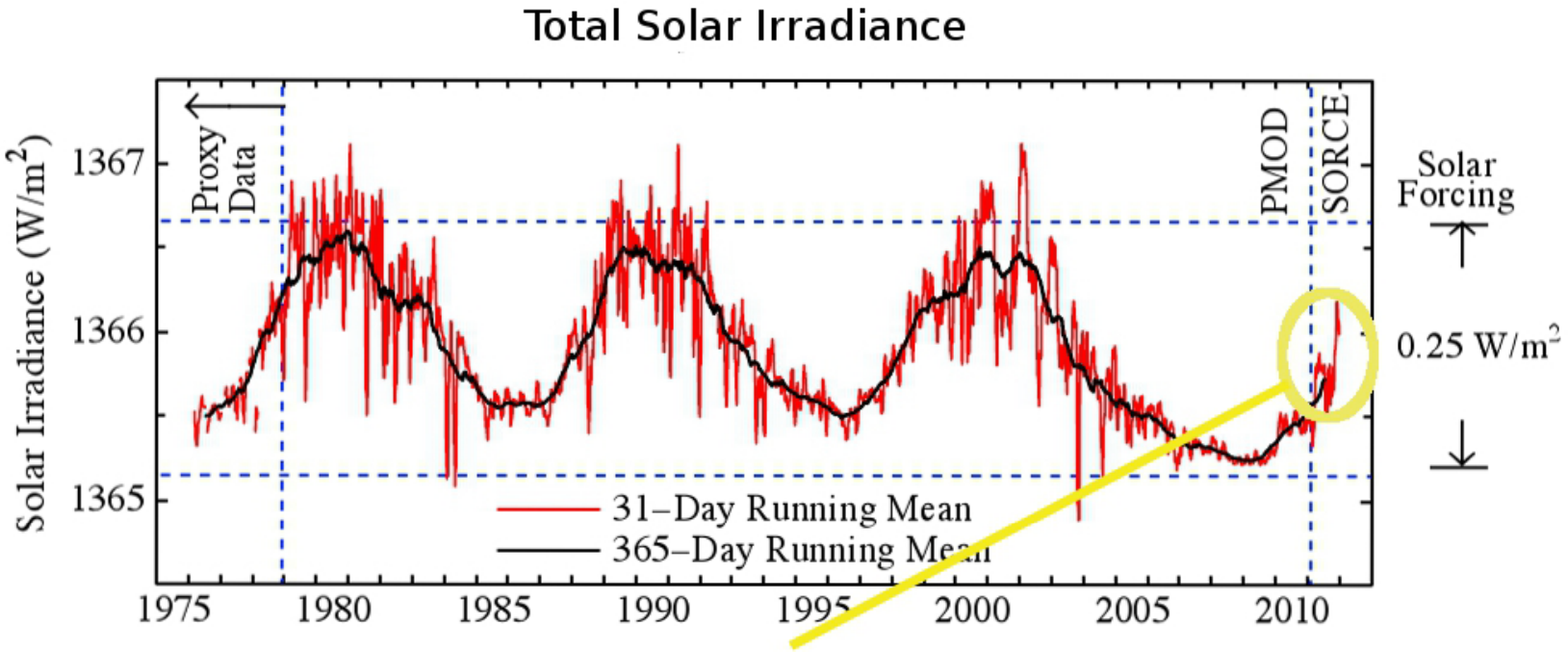




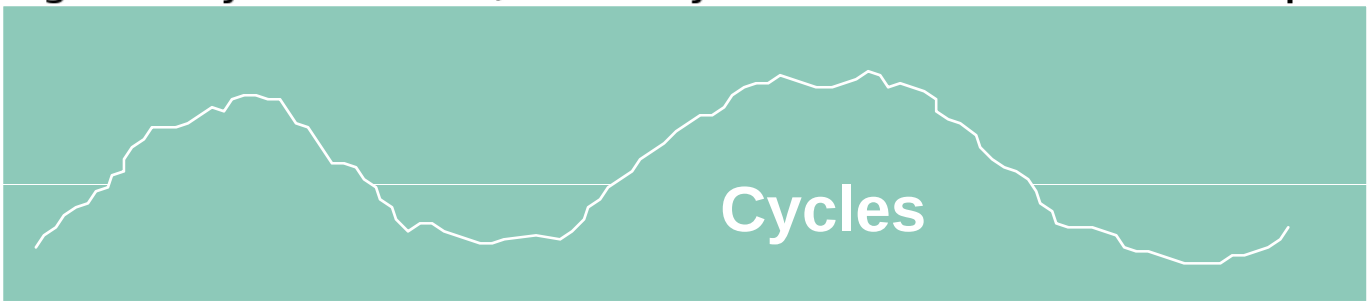
Time Series Methods (4/5)

✓ *Cycles:*

- **Wavelike variations of more than one year duration**



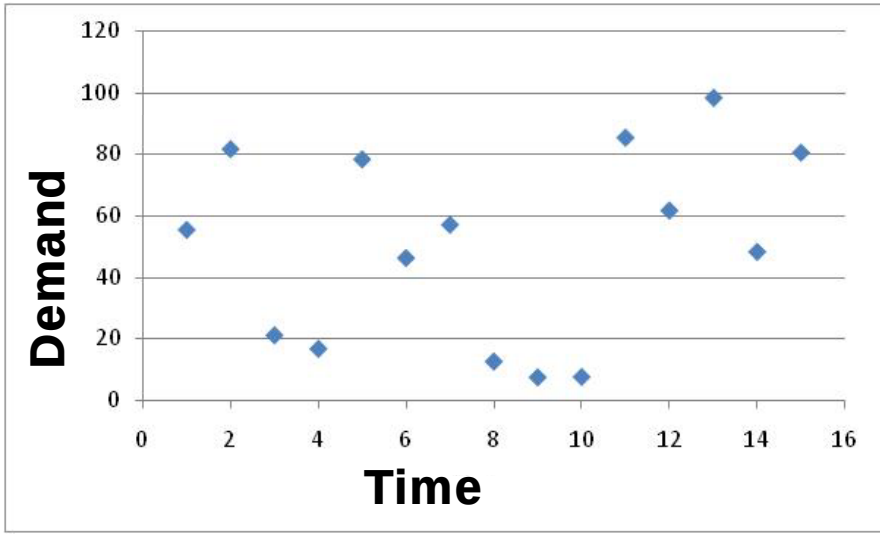
Warming already committed, but not yet manifest in surface temperature



Time Series Methods (5/5)

✓ *Random Variations - Stochasticity:*

- **There are no rules (values by chance)**



- **Example: Stock Market**
- **Models for Stock Market are characterized of High Levels of Difficulty**

Stationary Time Series Methods

✓ *Stationary time series:*

- **Represented by a constant plus a random fluctuation:**

$$Dt = \mu + \varepsilon_t$$

where μ is an unknown constant corresponding to the mean of the series and ε_t is a random error with mean 0 and variance σ^2 .

- **The methods described for stationary series are:**
  - **Simple Moving Average**
  - **Weighted Moving Average**
  - **Exponential Smoothing**

Simple Moving Average (1/10)

✓ *Simple Moving Average Forecasting Model (no trend, no seasonality)*

- **Simple moving average forecasting method uses historical data to generate a forecast. Works well when demand is fairly stable over time.**

$$F_t = \frac{\sum_{i=t-N}^{t-1} D_i}{N} = \frac{D_{t-1} + D_{t-2} + \ldots + D_{t-N}}{N}$$

where

F_t= Forecast for period *t*

N= Number of periods used to calculate moving average, and

D_i= Actual demand in period *i*

Simple Moving Average (2/10)

✓ ***Example 1:***

- **In the following Table the demand of product A is given per month**

Forecasts for N=3 & N=6 periods should be calculated (use of Moving Average)

Month	Demand
1	2
2	4
3	6
4	8
5	10
6	11
7	13
8	15
9	19
10	20
11	22
12	24

Simple Moving Average (3/9)

✓ ***Example 1:***

- **Formulas for the calculation of Moving Average and Forecast Error (N=3)**

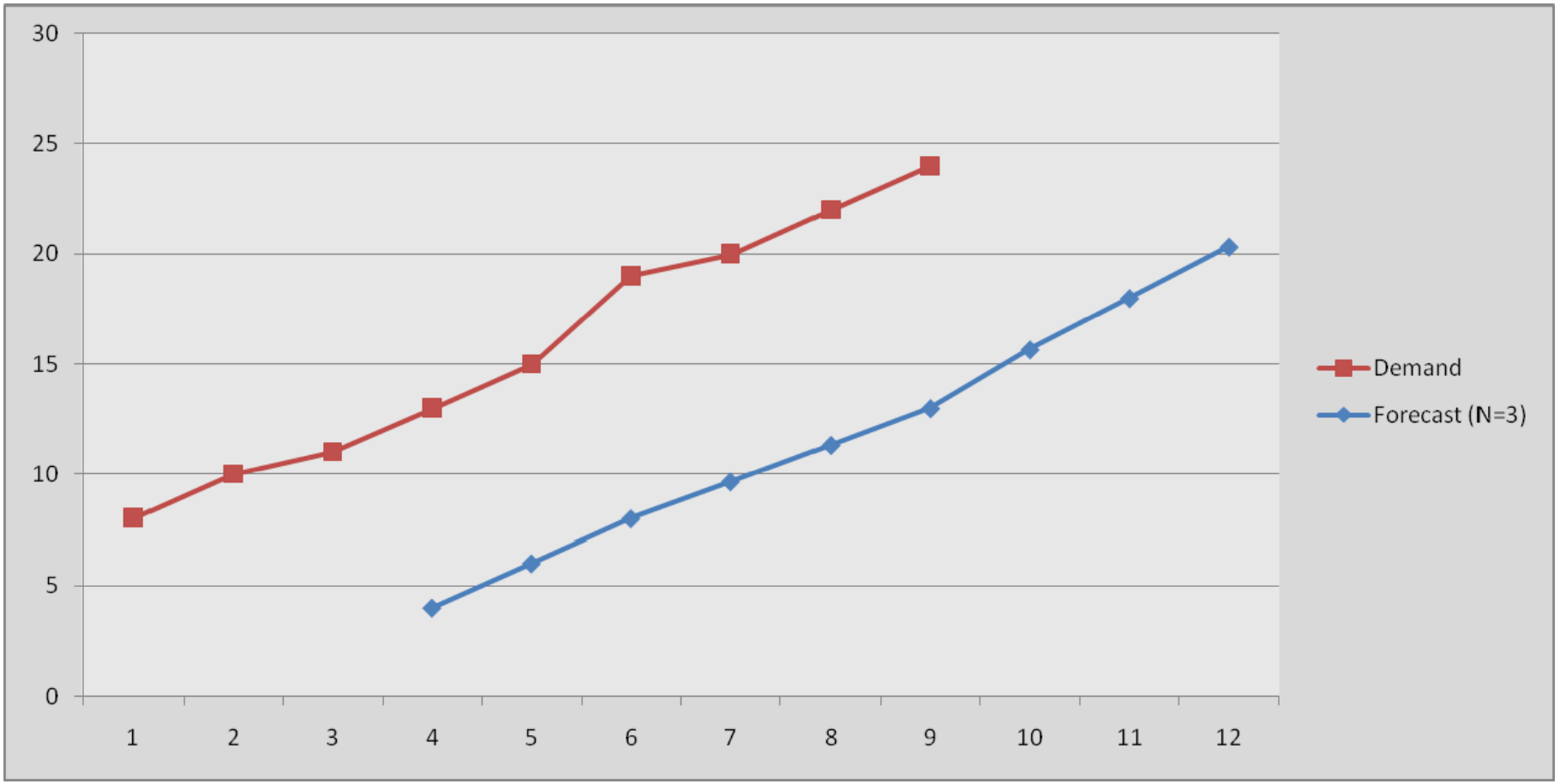
	A	B	C	D	E
1					
2		Month	Demand	Forecast (N=3)	Error
3		1	2		
4		2	4		
5		3	6		
6		4	8	4	-4
7		5	10	6	-4
8		6	11	8	-3
9		7	13	10	-3
10		8	15	11	-4
11		9	19	13	-6
12		10	20	16	-4
13		11	22	18	-4
14		12	24	20	-4
15					
16				=Average(C3:C5)	=C6-B6

Insert Function

Simple Moving Average (4/9)

✓ ***Example 1:***

- **N=3**



Simple Moving Average (5/9)

✓ ***Example 1:***

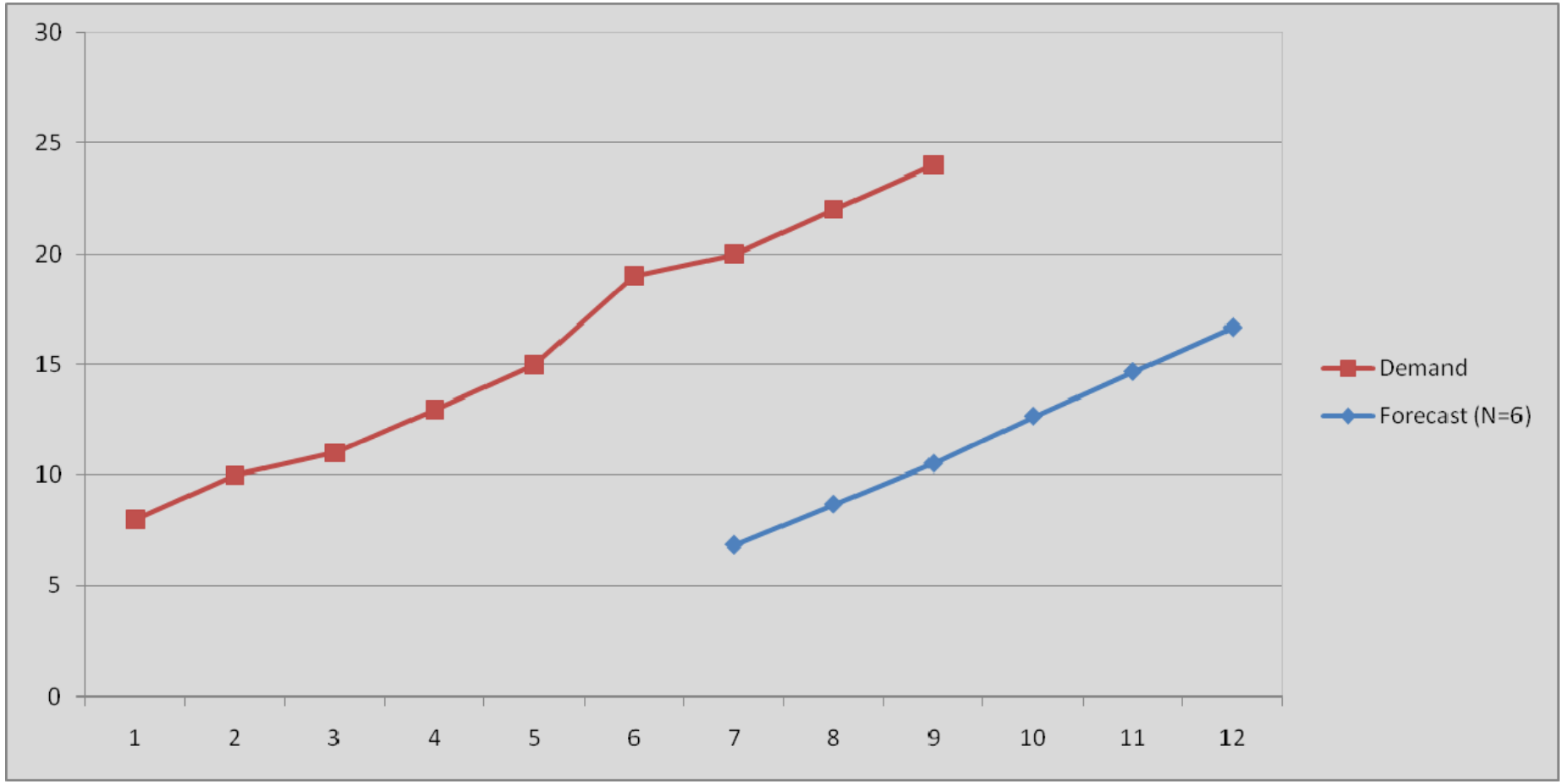
- **For N=6 the values of Moving Average and the Forecast Error are given**

	N	O	P	Q
1				
2	Month	Demand	Forecast (N=6)	Error
3	1	2		
4	2	4		
5	3	6		
6	4	8		
7	5	10		
8	6	11		
9	7	13	7	-6
10	8	15	9	-6
11	9	19	11	-9
12	10	20	13	-7
13	11	22	15	-7
14	12	24	17	-7
15				
16			=AVERAGE(O3:O8)	=P9-O9

Simple Moving Average (6/9)

✓ ***Example 1:***

- **N=6**



Simple Moving Average (7/9)

✓ ***Example 1:***

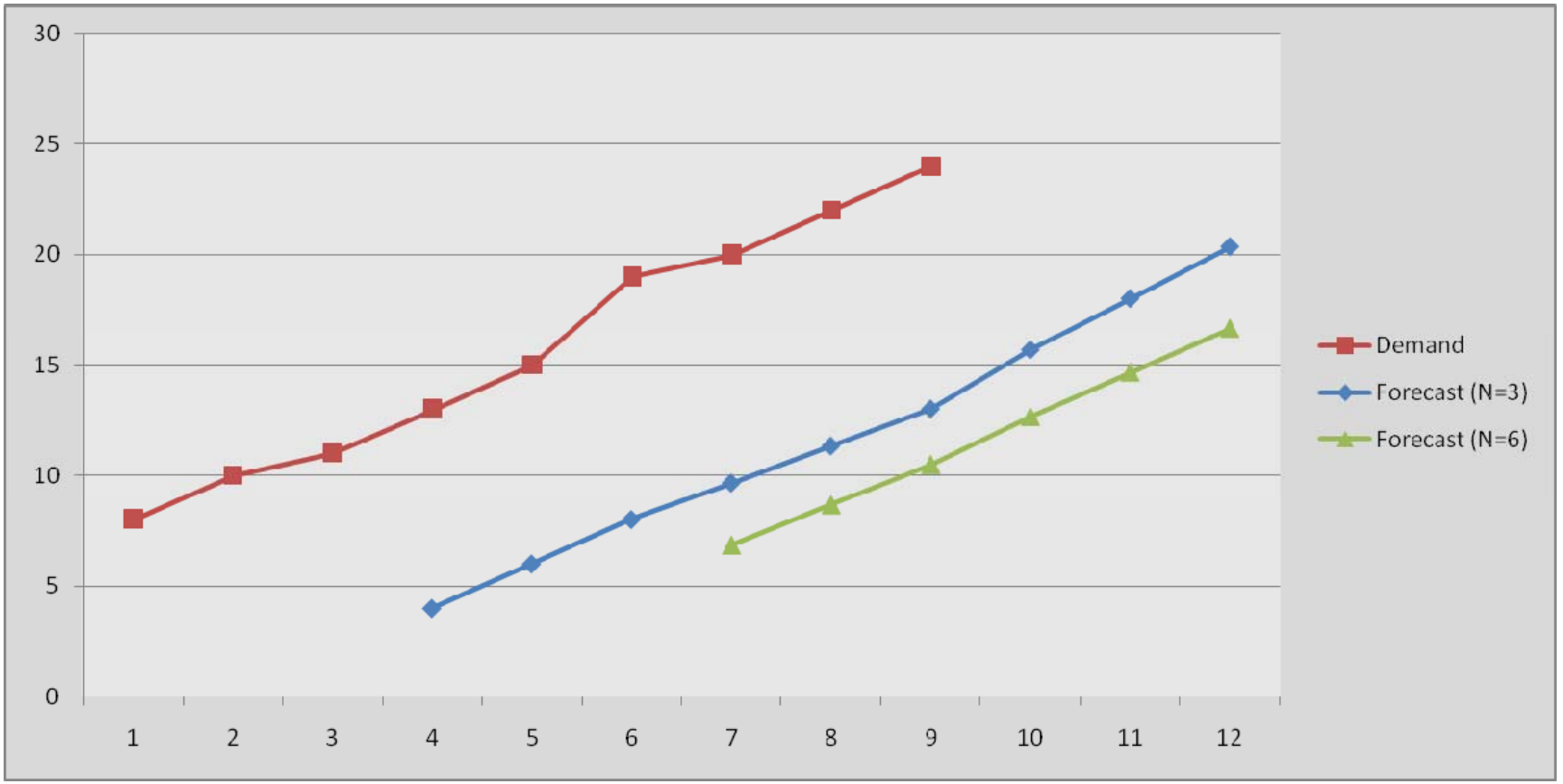
- **For N=3 & N=6 the Moving Average and the Forecast Error are given**

Month	Demand	Forecast (N=3)	Error	Forecast (N=6)	Error
1	2				
2	4				
3	6				
4	8	4	-4		
5	10	6	-4		
6	11	8	-3		
7	13	10	-3	7	-6
8	15	11	-4	9	-6
9	19	13	-6	11	-9
10	20	16	-4	13	-7
11	22	18	-4	15	-7
12	24	20	-4	17	-7

Simple Moving Average (8/9)

✓ ***Example 1:***

- **Moving Average Forecasts lag behind a trend**



Number of Periods = **Lag**

Simple Moving Average (9/9)

✓ ***Advantages:***

- **Easily understood**
- **Easily computed**
- **Provides stable forecasts**

✓ ***Disadvantages:***

- **Requires saving lots of past data points: at least the N periods used in the moving average computation**
- **Lags behind a trend**
- **Ignores complex relationships in data**

Weighted Moving Average (1/4)

✓ *Weighted Moving Average Forecasting Model (no trend, no seasonality)*

- **Based on an n-period weighted moving average. More recent values in a series are given more weight in computing the forecast.**

$$F_t = \frac{\sum_{i=t-N}^{t-1} w_i D_i}{N} = \frac{w_{t-1}D_{t-1} + w_{t-2}D_{t-2} + \ldots + w_{t-N}D_{t-N}}{N}$$

where

F_t= Forecast for period *t*

N= Number of periods used to calculate moving average, and

w_i = Weight assigned to period *i* (with $\Sigma w_i=1$)

D_i= Actual demand in period *i*

Weighted Moving Average (2/4)

✓ ***Example 2:***

- **In the following Table the demand of product A is given per month**

Forecasts for N=3 periods should be calculated (use of Weighted Moving Average)

Month	Demand
1	2
2	4
3	6
4	8
5	10
6	11
7	13
8	15
9	19
10	20
11	22
12	24

Weighted Moving Average (3/4)

✓ ***Example 2:***

- **For N=3 the values of Weighted Moving Average and the Forecast Error are given**

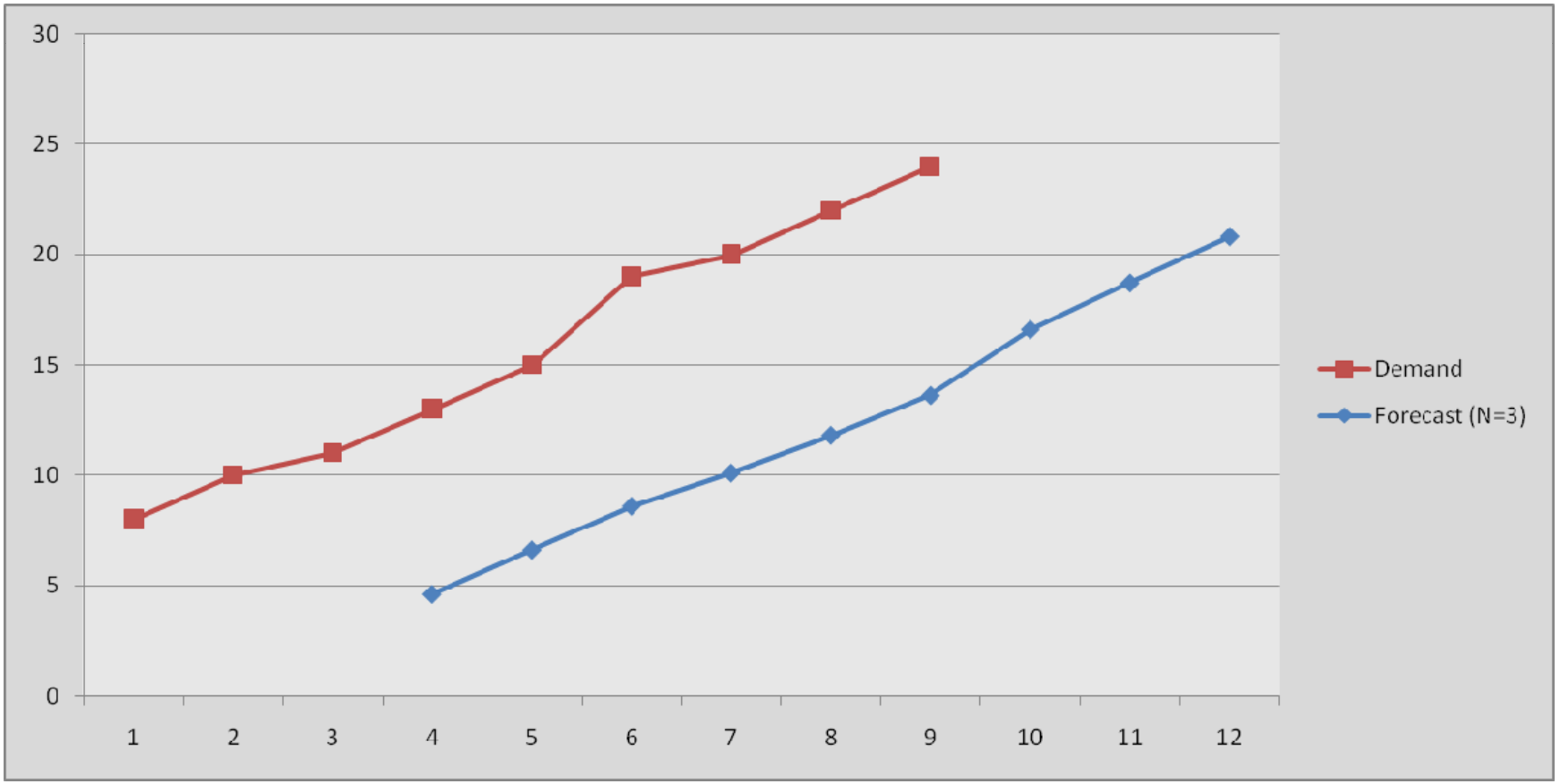
Month	Demand	Weight	Forecast (N=3)	Error
1	2	0,2		
2	4	0,3		
3	6	0,5		
4	8		5	-3
5	10		7	-3
6	11		9	-2
7	13		10	-3
8	15		12	-3
9	19		14	-5
10	20		17	-3
11	22		19	-3
12	24		21	-3

=SUMPRODUCT(C3:C5; D$3:D$5)

=C6-B6

Weighted Moving Average (4/4)

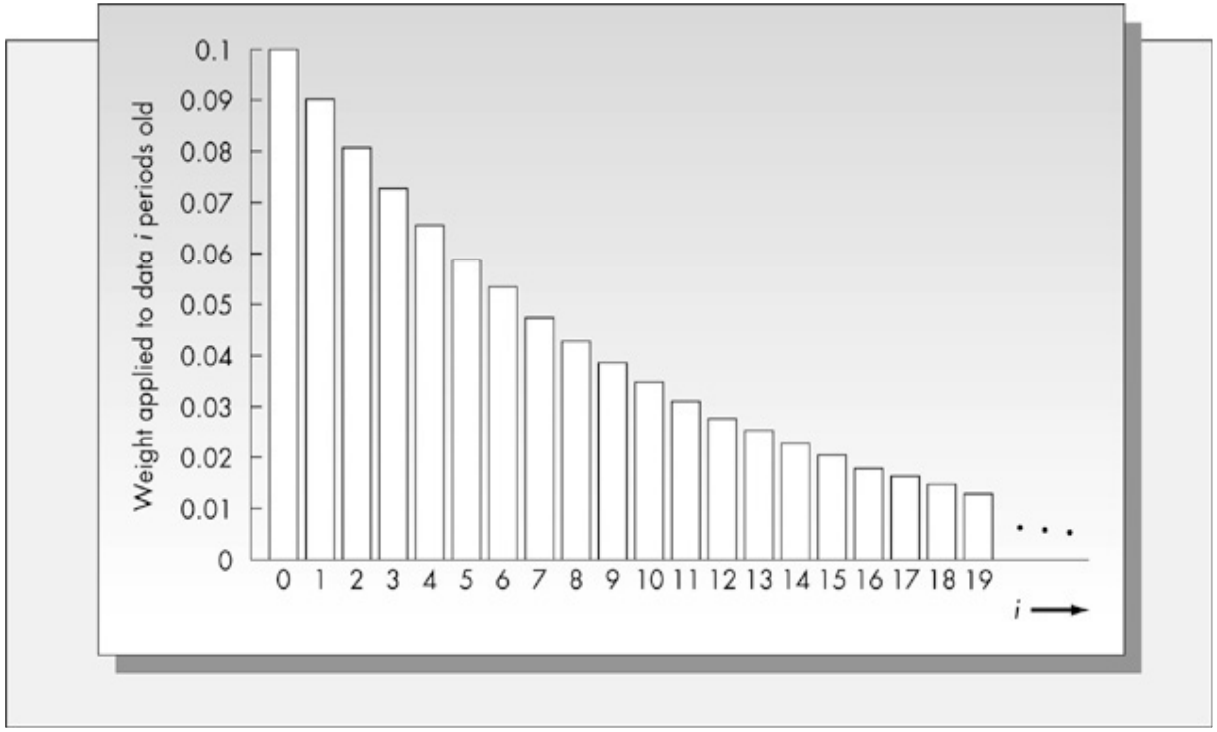
✓ ***Example 2:***



Exponential Smoothing(1/9)

✓ *Exponential Smoothing Model*

- **A weighted moving average in which the forecast for the next period's demand is the current period's forecast adjusted by a fraction of the difference between the current period's actual demand and its forecast.**
- **More recent data have highest weighting factor *α* (known as smoothing constant)**



Exponential Smoothing (2/9)

✓ *Exponential Smoothing Model (no trend, no seasonality)*

Current forecast is a weighted average of the last forecast and the current value of demand

New forecast = α * (current observation of demand) + (1- α) * (last forecast)

$$F_t = (1-a)F_{t-1} + aA_{t-1} \; or$$

$$F_t = F_{t-1} + a(A_{t-1} - F_{t-1})$$

where

F_t= Forecast for period *t*

F_{t-1}= Forecast for period *t-1*

A_{t-1}= Actual demand for period *t-1*

α= a smoothing constant (with 0≤α≥1)

Exponential Smoothing (3/9)

✓ ***Example 3:***

- **In the following Table the demand of product B is given per month**

  Forecasts values should be calculated (use of Exponential Smoothing)

  Values for a (a=0,1 & a=0,6)

Month	Demand (tn)
1	42,00
2	40,00
3	43,00
4	40,00
5	41,00
6	39,00
7	46,00
8	44,00
9	45,00
10	38,00
11	40,00
12	43,00

Exponential Smoothing (4/9)

✓ ***Example 3:***

- **Values for Forecast and Forecast Error (a=0,1)**

	A	B	C	D	E	F
1						
2				a=0,1		
3				0,1		
4		Month	Demand (tn)	Forecast (a=0,1)	Error	
5		1	42,00			
6		2	40,00	42,00	2,00	
7		3	43,00	41,80	-1,20	
8		4	40,00	41,92	1,92	
9		5	41,00	41,73	0,73	
10		6	39,00	41,66	2,66	
11		7	46,00	41,39	-4,61	
12		8	44,00	41,85	-2,15	
13		9	45,00	42,07	-2,93	
14		10	38,00	42,36	4,36	
15		11	40,00	41,92	1,92	
16		12	43,00	41,73	-1,27	
17						
18						

=C5

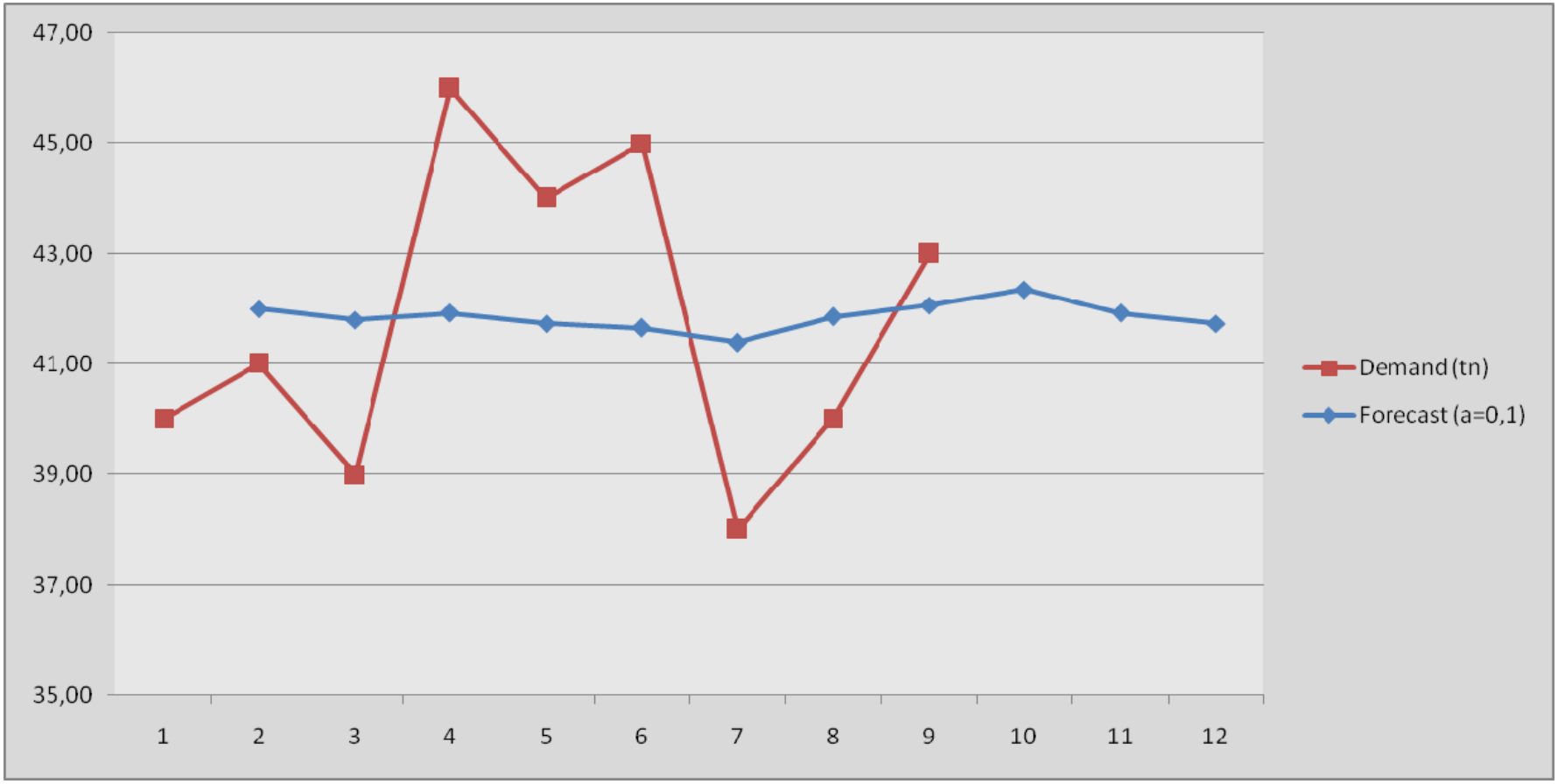
=D6-C6

=D5+D$2*(C5-D5)

Exponential Smoothing (5/9)

✓ ***Example 3:***

- **Graph (a=0,1)**



Exponential Smoothing(6/9)

✓ ***Example 3:***

- **Values for Forecast and Forecast Error (a=0,6)**

	J	K	L	M	N	O
1						
2				a=0,6		
3				0,6		
4		Month	Demand (tn)	Forecast (a=0,6)	Error	
5		1	42,00			
6		2	40,00	42,00	2,00	
7		3	43,00	40,80	-2,20	
8		4	40,00	42,12	2,12	
9		5	41,00	40,85	-0,15	
10		6	39,00	40,94	1,94	
11		7	46,00	39,78	-6,22	
12		8	44,00	43,51	-0,49	
13		9	45,00	43,80	-1,20	
14		10	38,00	44,52	6,52	
15		11	40,00	40,61	0,61	
16		12	43,00	40,24	-2,76	
17						
18						

=L5

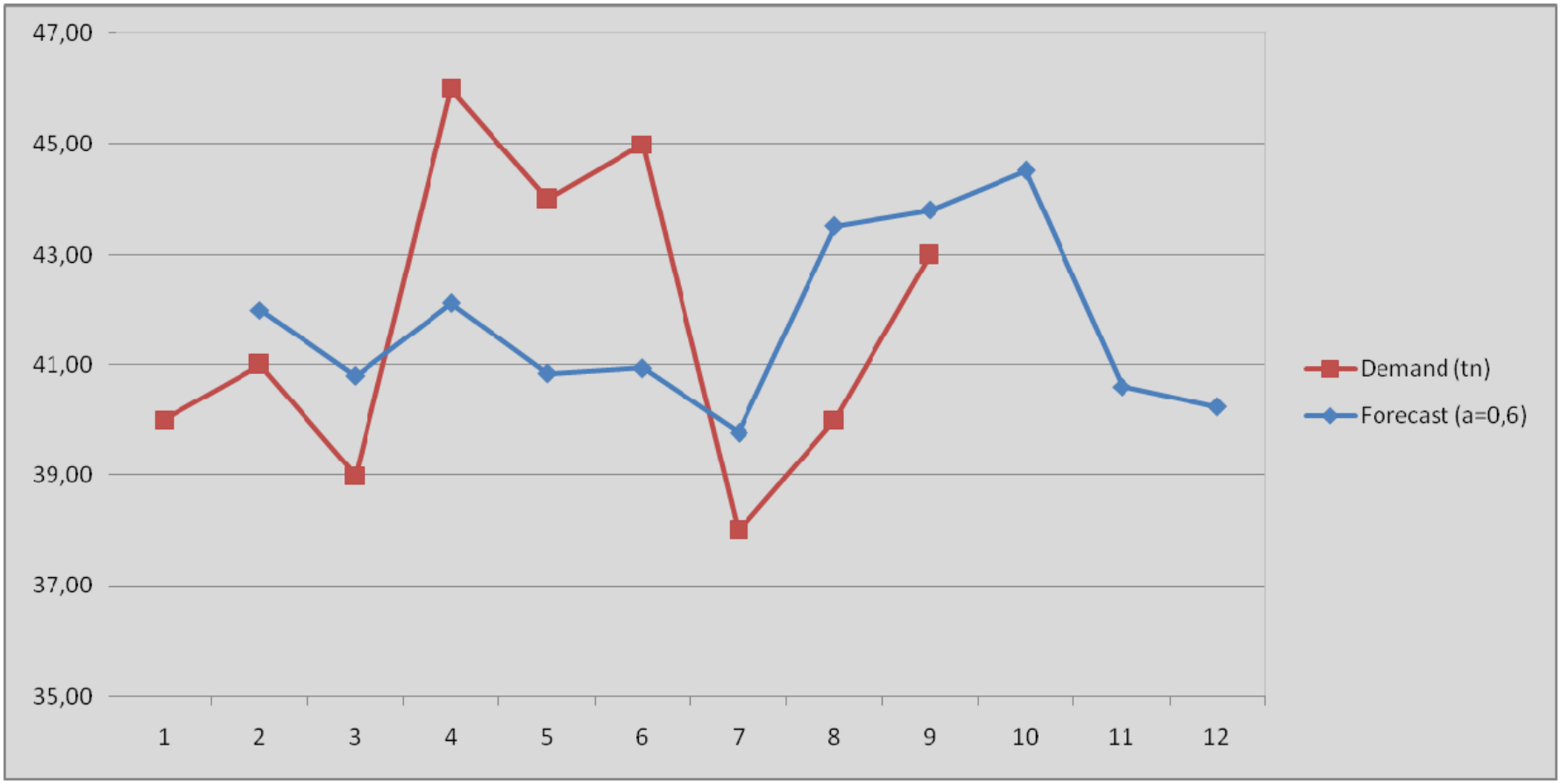
=M6-L6

=M6+$M$3*(L6-M6)

Exponential Smoothing (7/9)

✓ ***Example 3:***

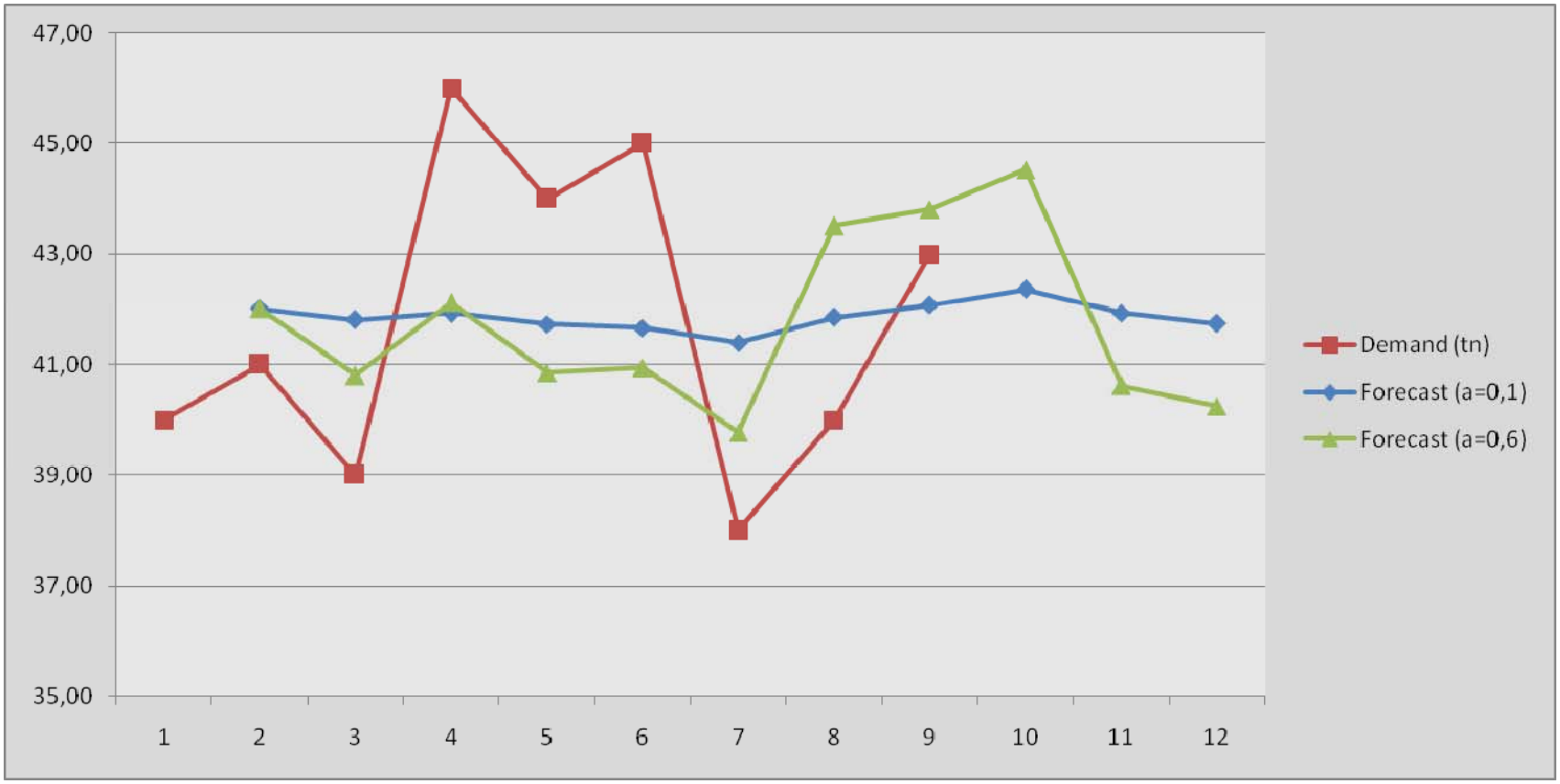
- **Graph (a=0,6)**



Exponential Smoothing (8/9)

✓ ***Example 3:***

- **Graph (a=0,3 & a=0,6)**



Observations for Trend?

Exponential Smoothing(9/9)

✓ ***Small Values of a:***

- **The forecasted value will be stable**
- **Increases the lag of the forecast to the actual data if a trend is present**

✓ ***Large Values of a:***

- **Forecast will more closely track the actual time series**

Moving Average vs. Exponential Smoothing

✓ ***Similarities:***

- **Both methods are appropriate for stationary series**
- **Both methods depend on a single parameter**
- **Both methods lag behind a trend**
- **One can achieve the same distribution of forecast error by setting: a = 2/ (N + 1) or N = (2 - a)/ a**

✓ ***Differences:***

- **Exponential Smoothing carries all past history**
- **Moving Average eliminates data after N periods**
- **Moving Average requires all N past data points to compute new forecast estimate while Exponential Smoothing only requires last forecast and last observation of 'demand' to continue**

Non Stationary Time Series Methods with Trend

✓ *Non-Stationary time series (with Trend):*

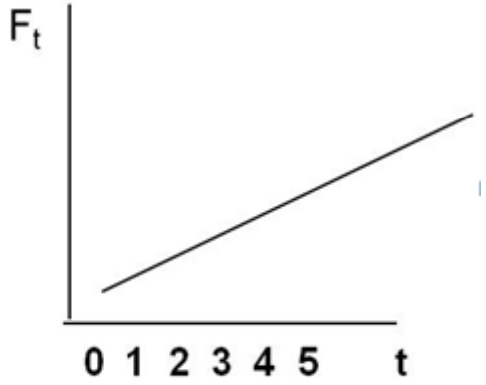
- **Linear Trend Forecasting Model**
- **Simple Regression Analysis**
- **Double Exponential Smoothing (Holt's Method)**

Linear Trend Forecasting Model (1/4)

✓ *Linear Trend Forecasting Model (with trend, no seasonality)*

The forecasting equation for the linear trend model is:

$$F_t = a + b\,t$$



where

F_t = Forecast for period t

t = Specified number of time periods

a = Intercept of the line

b = Slope of the line

Linear Trend Forecasting Model (2/4)

✓ *Calculating a and b*

$$b = \frac{n\sum(t\,y) - \sum t \sum y}{n\sum t^2 - (\sum t)^2}$$

$$a = \frac{\sum y - b\sum t}{n}$$

where

n = Total number of periods t

t = Period

y = Actual demand in period t

Linear Trend Forecasting Model (3/4)

✓ ***Example 4:***

- **In the following Table the Sales of product X is given per month**

  The forecasting equation for the linear trend model is requested

Month (t)	Sales (y)
1	42,00
2	40,00
3	43,00
4	40,00
5	41,00

Linear Trend Forecasting Model (4/4)

✓ ***Example 4:***

- **Values for a, b**

Month (t)	t^2	Sales (y)		
1	1	150,00	n	5
2	4	157,00	Σt	15
3	9	162,00	$(\Sigma t)^2$	225
4	16	166,00	Σt^2	55
5	25	177,00	Σy	812,00
			Σt*y	2499
			b	6,3
			a	143,5

=POWER(B7;2)

=COUNT(C7:C11)

=SUM(C7:C11)

=POWER(C12;2)

=SUM(D7:D11)

=SUM(E7:E11)

=SUMPRODUCT(C7:C11;E7:E11)

=((G6*G11)-(G7*G10))/((G6*G9)-G8)

=(G10-G12*G7)/G6

✓ ***Forecasting Equation*: Ft = 143,5+6,3*t**

Simple Regression (1/4)

✓ *Simple regression* *(with trend, no seasonality)*

One external (independent) variable is identified that is related to demand (dependent)

$$\hat{Y} = a + b \square X$$

where

$\hat{Y}$ = forecast or dependent variable

X = explanatory or independent variable

a = intercept of the line

b = slope of the line

Simple Regression (2/4)

✓ *Calculating a and b*

$$b = \frac{S_{xy}}{S_{xx}}$$

$$a = \bar{D} - b(n+1)/2$$

where

$$S_{xy} = n\sum_{i=1}^{n} D_i - \frac{n(n+1)}{2}\sum_{i=1}^{n} D_i$$

$$S_{xx} = \frac{n^2(n+1)(2n+1)}{6} - \frac{n^2(n+1)^2}{4}$$

$$\bar{D} = \frac{1}{n}\sum_{i=1}^{n} D_i$$

n=number of periods

D_i= actual demand of period i (i=1,….,n)

Simple Regression (3/4)

✓ ***Example 5:***

In the following Table the Sales of product X is given per month

The forecasting equation for the simple regression model is requested

Calculation of parameters a & b will be done with a basis of 5 months (set n=5)

Month	Demand
1	200
2	250
3	175
4	186
5	225
6	285
7	305
8	190

Simple Regression (4/4)

✓ ***Example 5:***

- **Values for a, b**

	G	H	I	J	K
3					
4	Month (X)	Demand (D)	ΣDi	1036	=SUM(H5:H9)
5	1	200	$\bar{D}$	207,2	=J4/5
6	2	250	n	5	Assumption of the Problem Set n=5
7	3	175	Σ(i*Di)	3094	=SUMPRODUCT(G5:G9;H5:H9)
8	4	186	n(n+1)/2	15	=J6*(J6+1)/2
9	5	225	n2(n+1)(2n+1)/6	275	=J6*J6*(J6+1)*(2*J6+1)/6
10	6	285	n2(n+1)2/4	225	=J6*J6*(J6+1)*(J6+1)/4
11	7	305	Σxy	-70	=J6*J7-J8*J4
12	8	190	Σxx	50	=J9-J10
13			b	-1,4	=J11/J12
14			a	211,4	=J5-J13*(J6+1)/2
15					

✓ ***Forecasting Equation***: $Y = 211,4 - 1,4 \square X$

Double Exponential Smooting (1/4)

- ✓ *Double Exponential Smoothing* *(with trend, no seasonality)*
  - ✓ **Holt's method is the most common example, can also be used to forecast when there is a linear trend present in the data. The method requires separate smoothing constants for slope and intercept.**
  - ✓ **The advantage is that once we begin building a forecast model, we can quickly revise the slope and signal constituents with the separate smoothing coefficients.**

Double Exponential Smooting (2/4)

✓ *Double Exponential Smoothing*

$$F_{t,t+\tau} = S_t + \tau G_t$$

where

$$S_t = \alpha D_t + (1-\alpha)(S_{t-1} + G_{t-1})$$ **Intercept at time t**

$$G_t = \beta(S_t - S_{t-1}) + (1-\beta)G_{t-1}$$ **Slope at time t**

$F_{t,t+\tau}$= Forecast for time τ into the future

D_t= Actual Demand in period t

α = smoothing constant ($0 \le \alpha \le 1$)

β = smoothing constant for trend ($0 \le \beta \le 1$)

Double Exponential Smooting (3/4)

✓ ***Example 6:***

In the following Table the Sales of product X is given per month

The forecasting values are requested

Known parameters: a=0,1 & b=0,1

Month	Demand
1	200
2	250
3	175
4	186
5	225
6	285
7	305
8	190

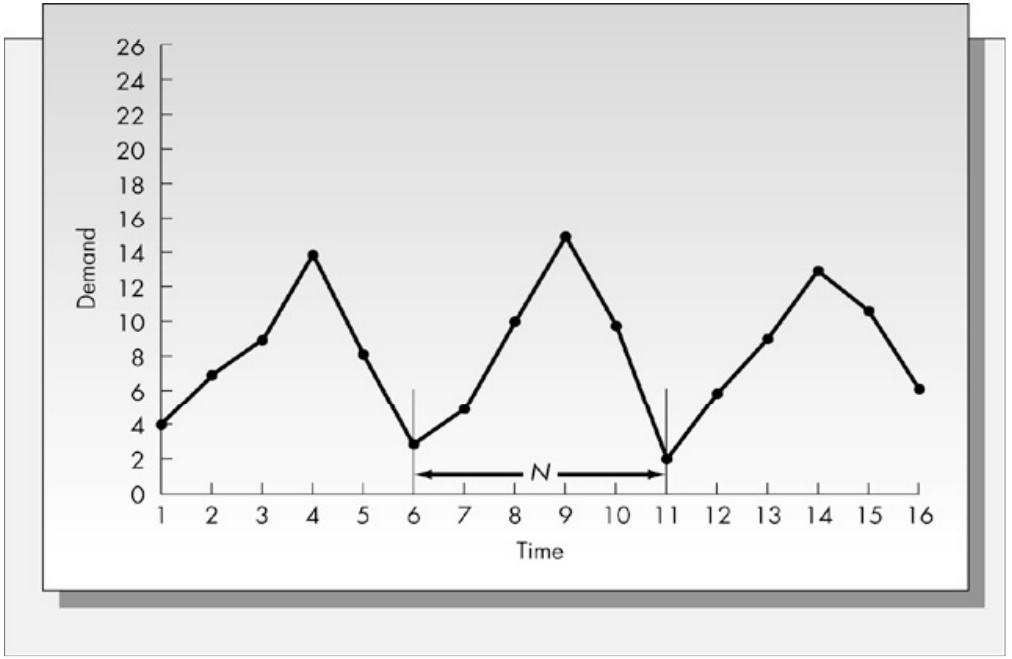
Double Exponential Smooting (4/4)

✓ ***Example 6:***

	B	C	D	E	F	G	H	I
3								
4		a	0,1	Set value a=0,1				
5		b	0,1	Set value b=0,1				
6	Month (X)	Demand (D)	S_t		G_t		F_t	
7			200	Set value So=200	10,00	Set value Go=10		
8	1	200	209	=D$4*C8+(1-D$4)*(D7+F7)	9,90	=D$5*(D8-D7)+(1-D$5)*F7		
9	2	250	222,01		10,21		232,22	=D9+F9
10	3	175	226,5		9,64		236,14	
11	4	186	231,12		9,14		240,26	
12	5	225	238,74		8,98		247,72	
13	6	285	251,45		9,36		260,81	
14	7	305	265,23		9,80		275,02	
15	8	190	266,52		8,95		275,47	
16								

Non Stationary Time Series Methods with Seasonality

Seasonality corresponds to a pattern in the data that repeats at regular intervals



N: Seasons

Non-Stationary time series (with Seasonality):

- **Seasonal Factors Stationary Time-Series**
- **Triple Exponential Smoothing (Winter's Method)**

Seasonal Factors Stationary Time-Series (1/3)

Seasonal Factors Stationary Time-Series *(with seasonality, no trend)*

Methodology employed

- **Compute the sample mean of the entire data set (should be at least several cycles of data)**
- **Divide each observation by the sample mean (This gives a factor for each observation)**
- **Average the factors for the same seasons**
- **The resulting n numbers will exactly add to N and correspond to the N seasonal factors.**

Seasonal Factors Stationary Time-Series (2/3)

✓ ***Example 7:***

In the following Table the total number (in tones) of Sales of product X is given per day for four weeks

TABLE 1

Day	Week 1	Week 2	Week 3	Week 4
Monday	16,2	17,3	14,6	16,1
Tuesday	12,2	11,5	13,1	11,8
Wednsday	14,2	15	13	12,9
Thursday	17,3	17,6	16,9	16,6
Friday	22,5	23,5	21,9	24,3

Seasonal Factors Stationary Time-Series (3/3)

✓ ***Example 7:***

TABLE 1

Day	Week 1	Week 2	Week 3	Week 4
Monday	16,2	17,3	14,6	16,1
Tuesday	12,2	11,5	13,1	11,8
Wednsday	14,2	15	13	12,9
Thursday	17,3	17,6	16,9	16,6
Friday	22,5	23,5	21,9	24,3

Average of all data: 16,425 — =AVERAGE(C6:F10)

TABLE 2

Day	DECESEASONILISED DATA Week 1	Week 2	Week 3	Week 4	Average of data in same seasons (c_t)	F_t
Monday	0,99	1,05	0,89	0,98	0,98	16,05
Tuesday	0,74	0,70	0,80	0,72	0,74	12,15
Wednsday	0,86	0,91	0,79	0,79	0,84	13,78
Thursday	1,05	1,07	1,03	1,01	1,04	17,10
Friday	1,37	1,43	1,33	1,48	1,40	23,05
				Σc_t	5,00	

=AVERAGE(D16:G16)

=D6/$D$12

=H16*$D$12

=SUM(H16:I20)

Triple Exponential Smoothing (Winter's Method) (1/8)

Winter's Method *(with seasonality, with trend)*

$$F_{t,t+t} = (S_t + tG_t) * c_{t+t-N}$$

where

$$S_t = \alpha(D_t / c_{t-N}) + (1-\alpha)(S_{t-1} + G_{t-1})$$

Deseasonalized Time Series:Signal

$$G_t = \beta(S_t - S_{t-1}) + (1-\beta)G_{t-1}$$

Trend

$$c_t = \gamma(D_t / S_t) + (1-\gamma)c_{t-N}$$

Seasonal Factors

$F_{t,t+t}$= Forecast for time t into the future

D_t= Actual Demand in period t

α = smoothing constant ($0 \le \alpha \le 1$)

β = smoothing constant for trend ($0 \le \beta \le 1$)

γ = smoothing constant ($0 \le \gamma \le 1$)

Triple Exponential Smoothing (Winter's Method) (2/8)

Starting the Winter's Method

- Derive initial estimates of the 3 values: S_t, G_t and c_t
- Typically we set: $\alpha = 2\beta = 2\gamma$ (A typical value for α=0,2
- Deriving initial estimates takes at least two complete cycles of data

Triple Exponential Smoothing (Winter's Method) (3/8)

Starting the Winter's Method……

Compute sample means for each cycle of data (V1 and V2)

$$V_1 = \frac{1}{N} \sum_{j=-2N+1}^{-N} D_j$$

Average Demand for 2 cycles ago

$$V_2 = \frac{1}{N} \sum_{j=-N+1}^{0} D_j$$

Average Demand in the last cycle

$$G_0 = \left(V_2 - V_1\right) \Big/ \mathrm{N}$$

Slope estimation

where

N: Number of seasons

j=0: Today

Estimation of Signal and Seasonal Factor

$$S_0 = V_2 + G_0 \left[(N-1)/2 \right]$$

Signal Estimation

$$c_t = D_t \Big/ \left[V_i - \left(\left(\frac{N+1}{2} \right) - j \right) * G_0 \right]$$

Seasonal Factor Estimation

$$for \; -2N+1 \le t \le 0$$

Triple Exponential Smoothing (Winter's Method) (5/8)

Normalizing Seasonal Factor

$$c_j = \left[\frac{c_j}{\sum_{i=0}^{-N+1} c_i} \right] * N$$

$$for - N + 1 \leq j \leq 0$$

Triple Exponential Smoothing (Winter's Method) (6/8)

✓ ***Example 8:***

- **In the following Table the Sales of product X is given per quarter**

	Quarter	Demand
Year 1	1	10
	2	20
	3	26
	4	17
Year 2	5	12
	6	23
	7	30
	8	22

Triple Exponential Smoothing (Winter's Method) (78)

✓ ***Example 8:***

	Quarter	Demand
Year 1	1	10
	2	20
	3	26
	4	17
Year 2	5	12
	6	23
	7	30
	8	22

N	4
V_1	18,25
V_2	21,75
G_0	0,875
S_0	23,06
c_1	0,59
c_2	1,123
c_3	1,391
c_4	0,869
c_5	0,587
c_6	1,079
c_7	1,352
c_8	0,954

No. of quarters per year

=SUM(D4:D7)/G3

=SUM(D8:D11)/G3

=(G5-G4)/G3

=G5+G6*((G3-1)/2)

=D4/($G$4-(($G$3+1)/2 C4)*$G$6)

C_{-1}	0,589
C_{-2}	1,101
C_{-3}	1,372
C_{-4}	0,911
$F_{0,1}$	14,09
$F_{0,2}$	27,32
$F_{0,3}$	35,24
$F_{0,4}$	24,21

=(G8+G12)/2

=($G$7+C4 *$G$6)*J3

Triple Exponential Smoothing (Winter's Method) (8/8)

✓ ***Example 8:***

Take into account that in quarter 9 (t=1) the observed value of demand is D_1=16 and a=0.2,

β=0.1 & γ=0.1

	Quarter	Demand
Year 1	1	10
	2	20
	3	26
	4	17
Year 2	5	12
	6	23
	7	30
	8	22

C_{-1}	0,5888
C_{-2}	1,101
C_{-3}	1,3717
C_{-4}	0,9115
a	0,2
β	0,1
γ	0,1
D_1	16
G_0	0,875
S_0	23,063

S_1	24,58
G_1	0,94
c_1	0,595
F1,2	28,1
F1,3	36,3
F1,4	24,98

=G8*(J3-G12)+(1-G8)*G11

=G9*(G10/J3)+(1-G9)*G3

=($J$3+C4*$J$4)*G4

Synopsis of Forecasting Methods (1/2)

	TREND		SEASONALITY	
	Yes	No	Yes	No
Simple Moving Average		X		X
Weighted Moving Average		X		X
Exponential Smoothing		X		X
Linear Trend Forecasting Model	X			X
Simple Regression Analysis	X			X
Double Exponential Smoothing (Holt's Method)	X			X
Seasonal Factors Stationary Time-Series		X	X	
Triple Exponential Smoothing (Winter's Method)	X		X	

Synopsis of Forecasting Methods (2/2)

Choosing a Forecasting Technique

- ✓*No single technique works in every situation*
- ✓*Important factors*
  - *Cost*
  - *Accuracy*
- ✓*Other factors include the availability of:*
  - *Historical data*
  - *Software available*
  - *Time needed to gather and analyze the data*
  - *Forecast horizon*

Evaluating Forecasts (1/5)

Forecast Error in Period t:

$$E_t = Y_t - F_t$$

where

E_t = forecast error for Period t

Y_t = actual demand for Period t

F_t = forecast for Period t

Evaluating Forecasts (2/5)

Criteria for evaluation

Mean Absolute Error (Deviation) (MAD): ***a MAD of 0 indicates the forecast exactly predicted demand***

$$MAD = \frac{\sum_{t=1}^{N} |E_t|}{N}$$

Mean Squared Error (Deviation) (MSE): ***Analogous to variance, large forecast errors are heavily penalized***

$$MSE = \frac{\sum_{t=1}^{N} E_t^2}{N}$$

Mean Absolute Percentage Error: ***provides perspective of the true magnitude of the forecast error***

$$MAPE = \frac{\sum_{t=1}^{N} \left| \frac{E_t}{Y_t} \right|}{N}$$

Evaluating Forecasts (3/5)

Example 9

	B	C	D	E	F	G	H	I	J
1									
2									
3									
4	Month (X)	Demand (D)	Y_t	E_t	$[E_t]$	E_t^2	$[E_t]/Y_t$	MAD	31,67
5	1	200	232	-32	32	1038	0,14	MSE	1447
6	2	250	236	14	14	192	0,06	MAPE	0,13
7	3	175	240	-65	65	4259	0,27		
8	4	186	248	-62	62	3809	0,25		
9	5	225	261	-36	36	1282	0,14		
10	6	285	275	10	10	100	0,04		
11	7	305	275	30	30	872	0,11		
12	8	190	195	-5	5	25	0,03		
13									

=C5-D5

=ABS(E5)

=F5*F5

=F5/D5

=SUM(F5:F12)/8

=SUM(G5:G12)/8

=SUM(H5:H12)/8

Evaluating Forecasts (4/5)

Forecast Error Control Chart:

A visual tool for monitoring forecast errors

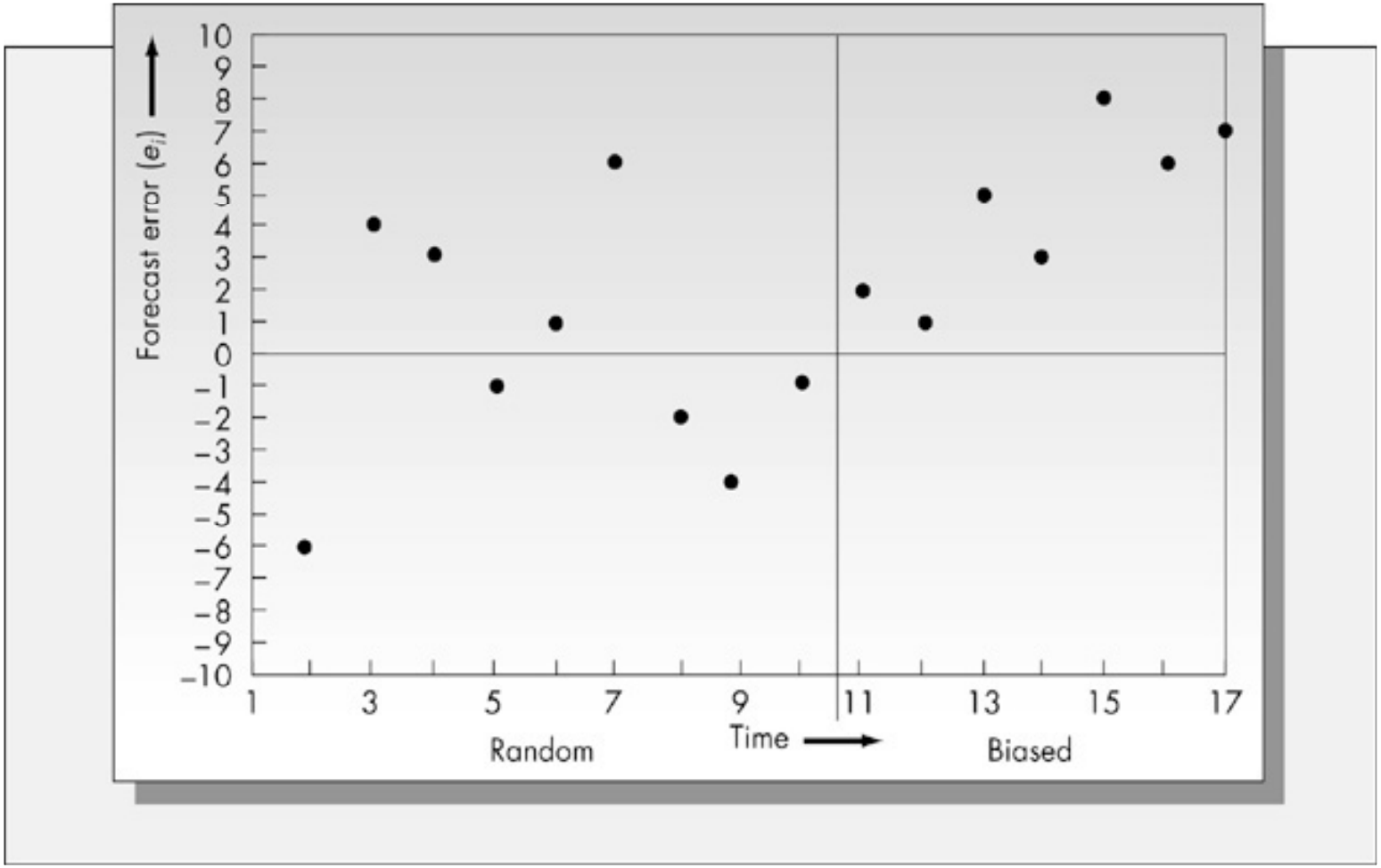
Used to detect non-randomness in errors

Forecasting errors are in control if

- ***All errors are within the control limits***
- ***No patterns, such as trends or cycles, are present***

Evaluating Forecasts (5/5)

Example of a Forecast Error Control Chart



Softwares for Forecasting

- ✓ *Excel .*
- ✓ *Crystal Ball (CB Predictor).*
- ✓ *SAS.*
- ✓ *SPSS.*
- ✓ *MICROFIT.*
- ✓ *EVIEWS.*
- ✓ *Forecast Pro.*

Introduction to CB Predictor™ (1/16)

CB Predictor™

- ✓ *is an addition to the Crystal Ball suite of decision intelligence products*
- ✓ *is for the planner and forecaster in every organization*
- ✓ *has a wide range of forecasting applications*
- ✓ *runs on several versions of Microsoft Windows and Microsoft Excel*

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Introduction to CB Predictor™ (2/16)

Shampoo Sales Tutorial

- ✓ *Role: Sales manager for Tropical Cosmetics Co.*
- ✓ *Product: Tropical Shampoo (company's latest product)*
- ✓ *Historical Data: Sales for a 9 month period*
- ✓ *Decision: Forecast the rest of the year's sales of shampoo and decide whether to recommend investing in advertising or enhancements for this product.*

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Shampoo Sales Tutorial

✓ 1: Start Crystal Ball and Excel.

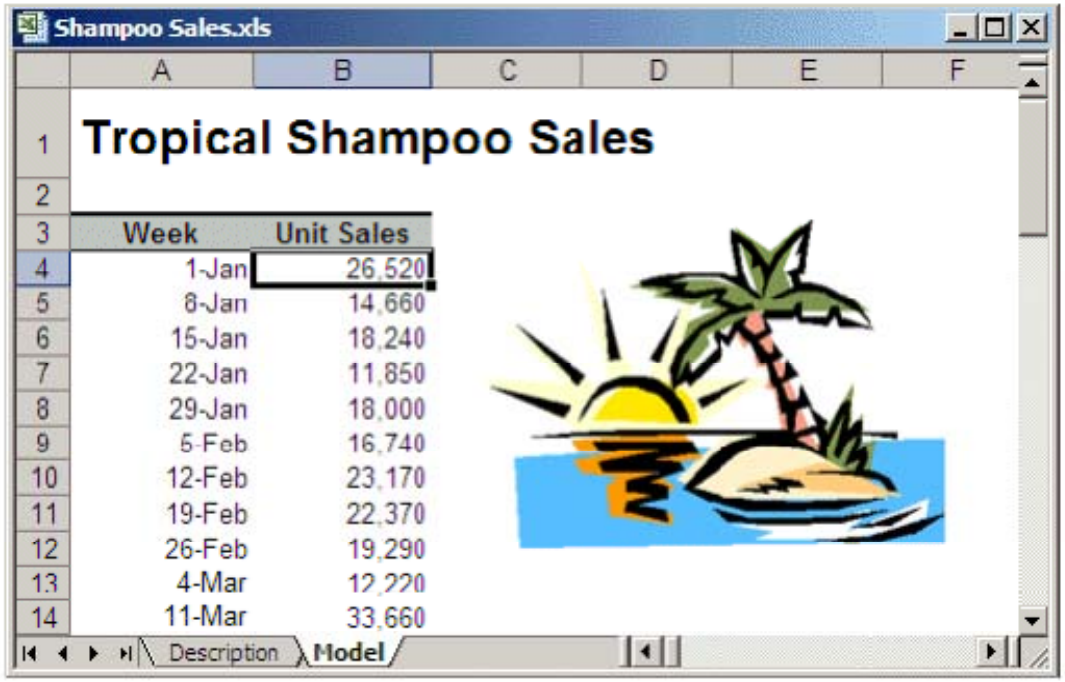
✓ 2: Open the Shampoo Sales spreadsheet from the Examples folder.

By default, the file is stored in this folder:

C:\Program Files\Oracle\Crystal Ball\Examples\CB Predictor Examples.

Shampoo Sales Tutorial

Figure 1–1 Shampoo Sales spreadsheet



There is one column of Tropical shampoo sales data next to a column with dates from January 1, 2004 until September 23, 2004. You need to forecast sales through the end of the year, December 31, 2004.

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Shampoo Sales Tutorial

✓**3:** *Select cell B4. Selecting any one cell in your data range, headers, or date range initiates CB Predictor's "Intelligent Input" to select all the filled, adjacent cells.*

✓**4:** *Select Run > CB Predictor. This command is only available if no simulation is running and the last run was reset. If necessary, wait for a simulation to stop or reset the last simulation.*

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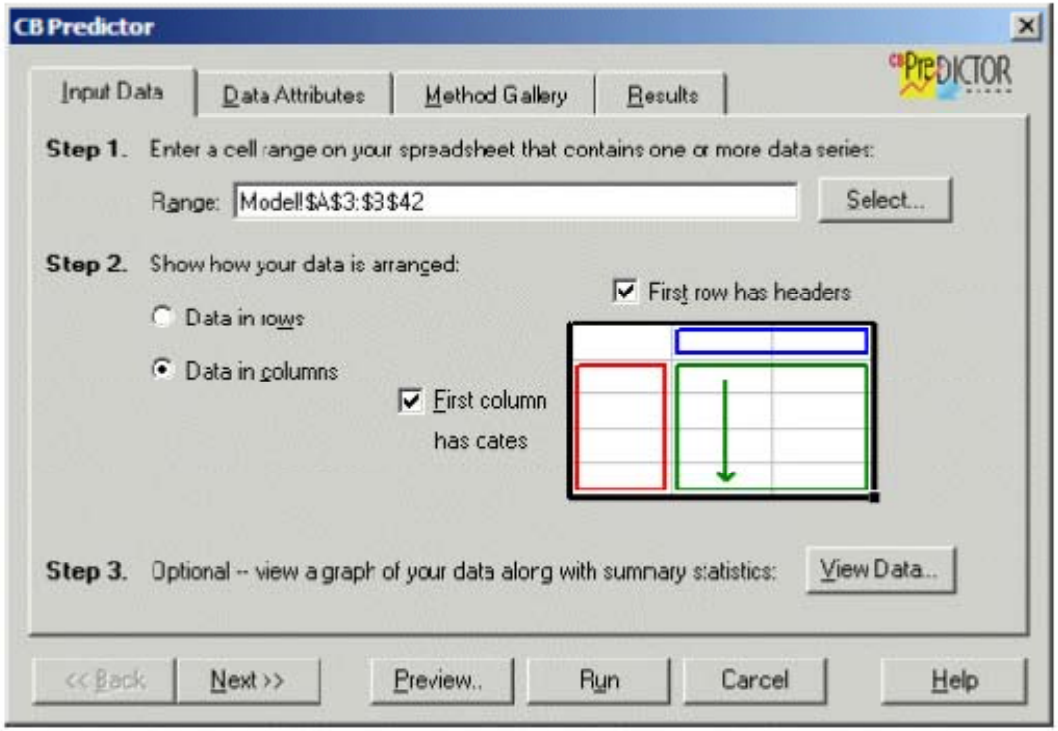
Shampoo Sales Tutorial

Figure 1–2 CB Predictor wizard, Input Data tab



✓ **5:** ***Insert the range and click next. The Data Attributes tab appears as shown in Figure 1–3.***

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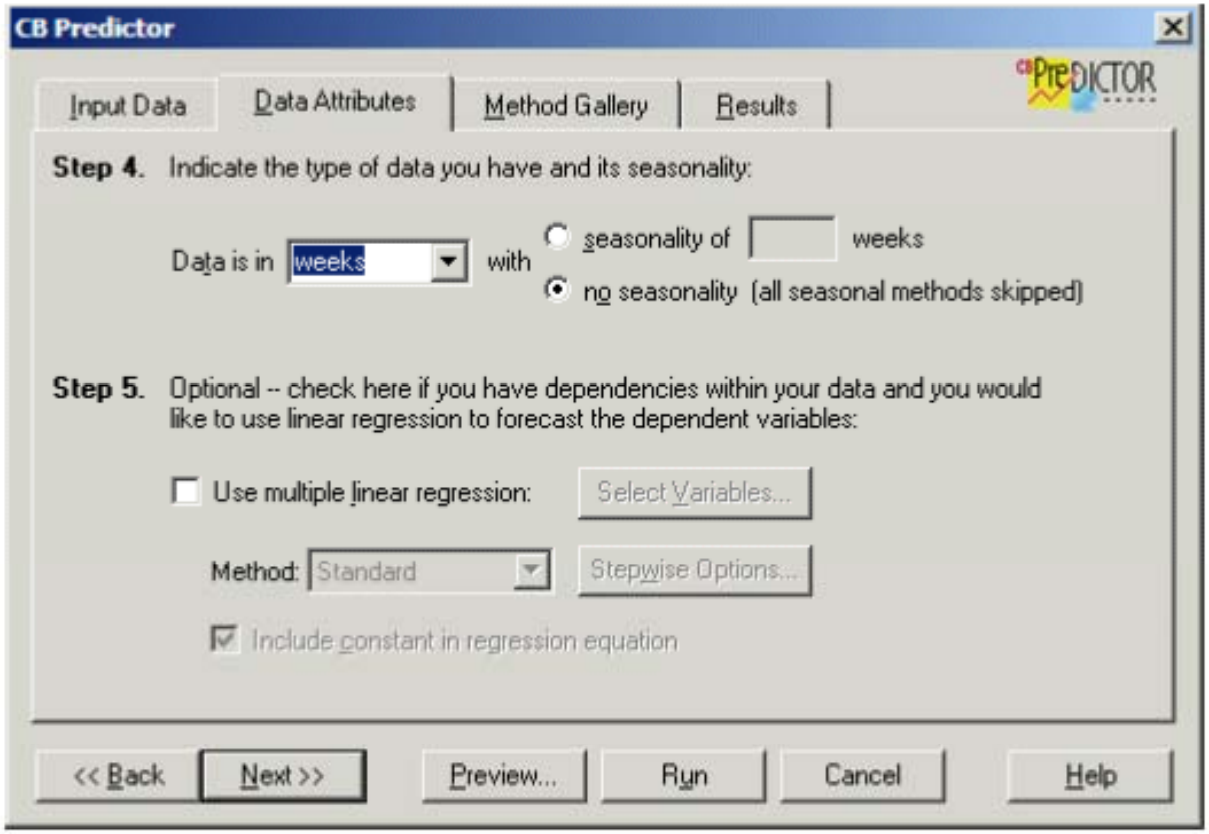
Shampoo Sales Tutorial

Figure 1–3 CB Predictor wizard, Data Attributes tab



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Shampoo Sales Tutorial

- ✓ 6: Under Step 4:
  - ✓ A. Select "weeks" from the Data Is In list.
  - ✓ B. Set the data to have no seasonality. (You have less than two complete seasons (cycles) of data, so cannot use seasonality.
- ✓ 7: Under Step 5, make sure that Use Multiple Linear Regression is not checked. (You did not choose regression because you have only one series of data, so there are no dependencies between series requiring regression.)
- ✓ 8: Click Next

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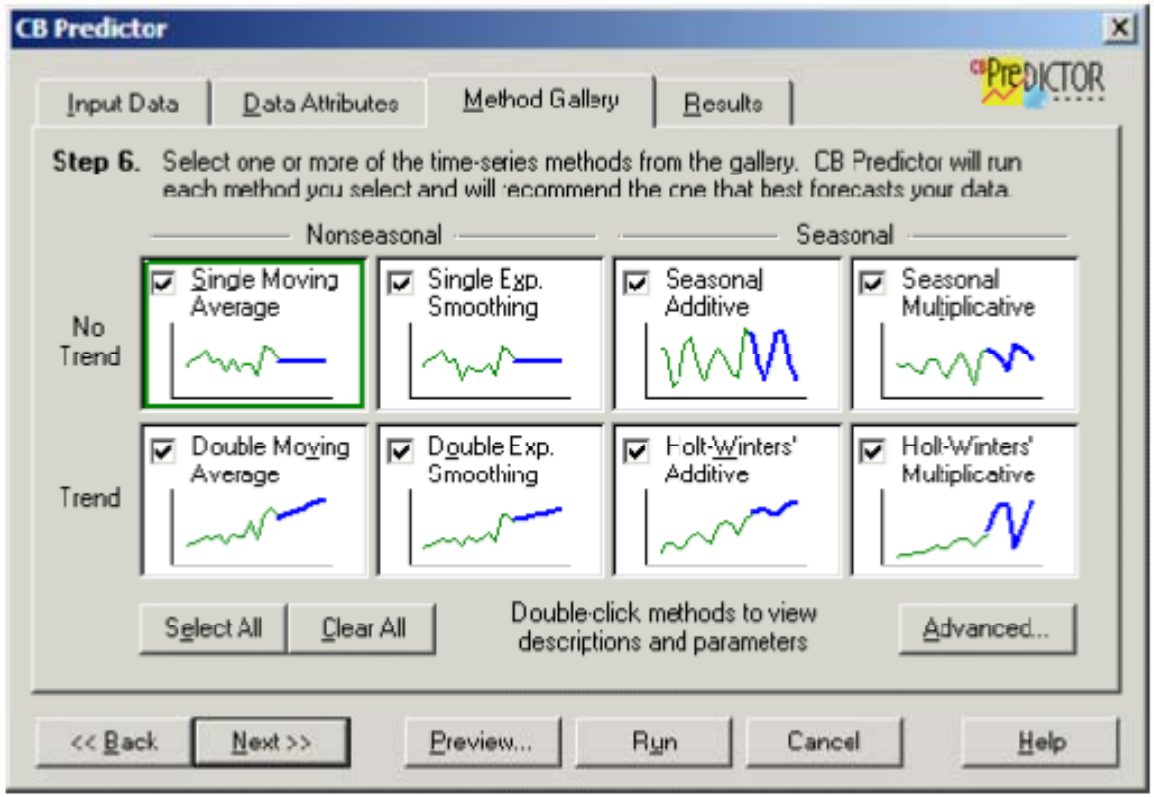
Shampoo Sales Tutorial

Figure 1–4 CB Predictor wizard, Method Gallery tab



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Shampoo Sales Tutorial

✓**9:** *Click Select All. This selects all the time-series forecasting methods, but CB Predictor doesn't use the seasonal methods, since you indicated that your data were not seasonal. CB Predictor forecasts your values using each of the selected methods and ranks them according to how well they fit the historical data. CB Predictor uses the seasonal methods as well as the nonseasonal methods if you indicate on the Data Attributes tab that your data series have seasonality.*

✓**10:** *Click Next. The Results tab appears as shown in Figure 1–5. The only output selected by default is Paste Forecast, which adds the forecasted values to the end of your historical data as shown in Figure 1–5.*

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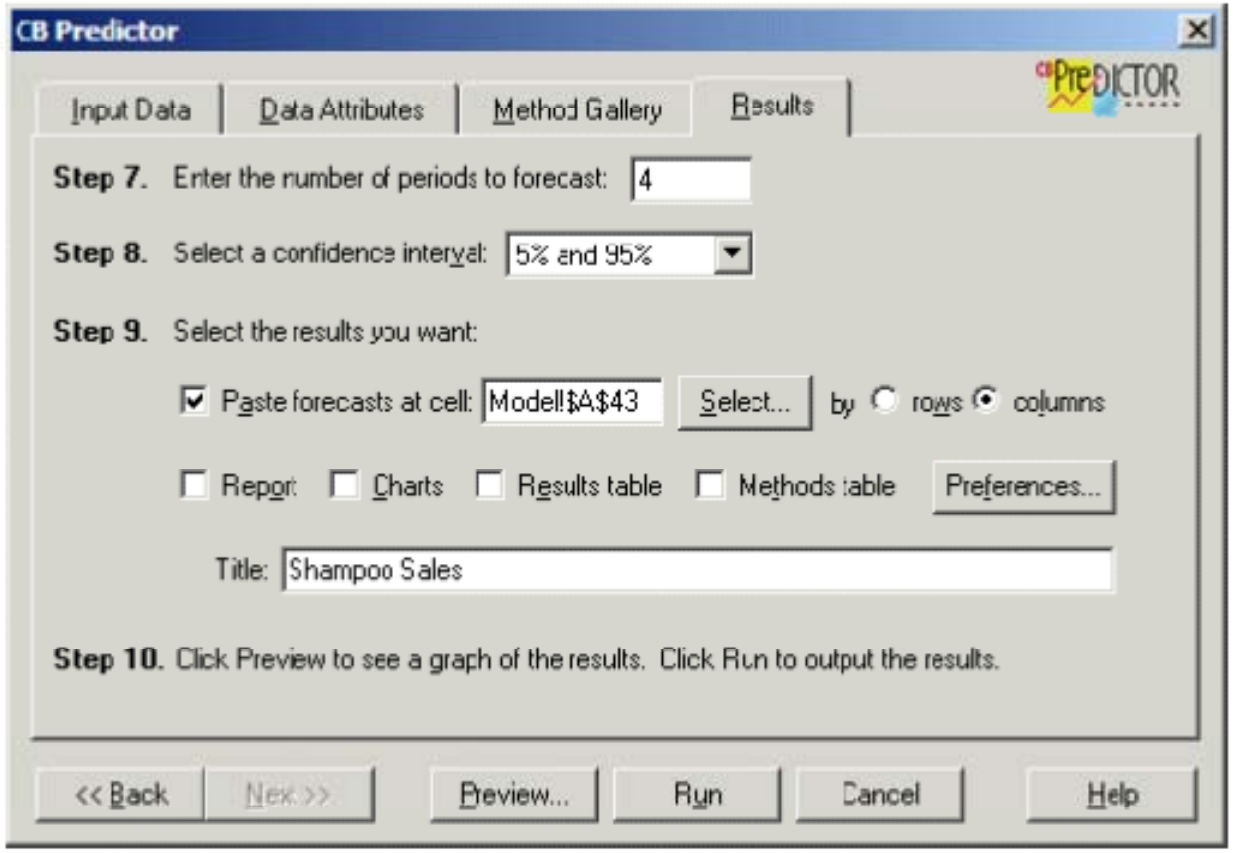
Shampoo Sales Tutorial

Figure 1–5 CB Predictor wizard, Results tab



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Shampoo Sales Tutorial

✓**11:** *Under Step 7, forecast the weekly sales for the rest of the year by entering 13 in the field.*

✓**12:** *Click Preview. The Preview Forecast dialog appears. It presents a graph with historical data, fitted data, forecast values, and confidence intervals as shown in Figure 1–6.*

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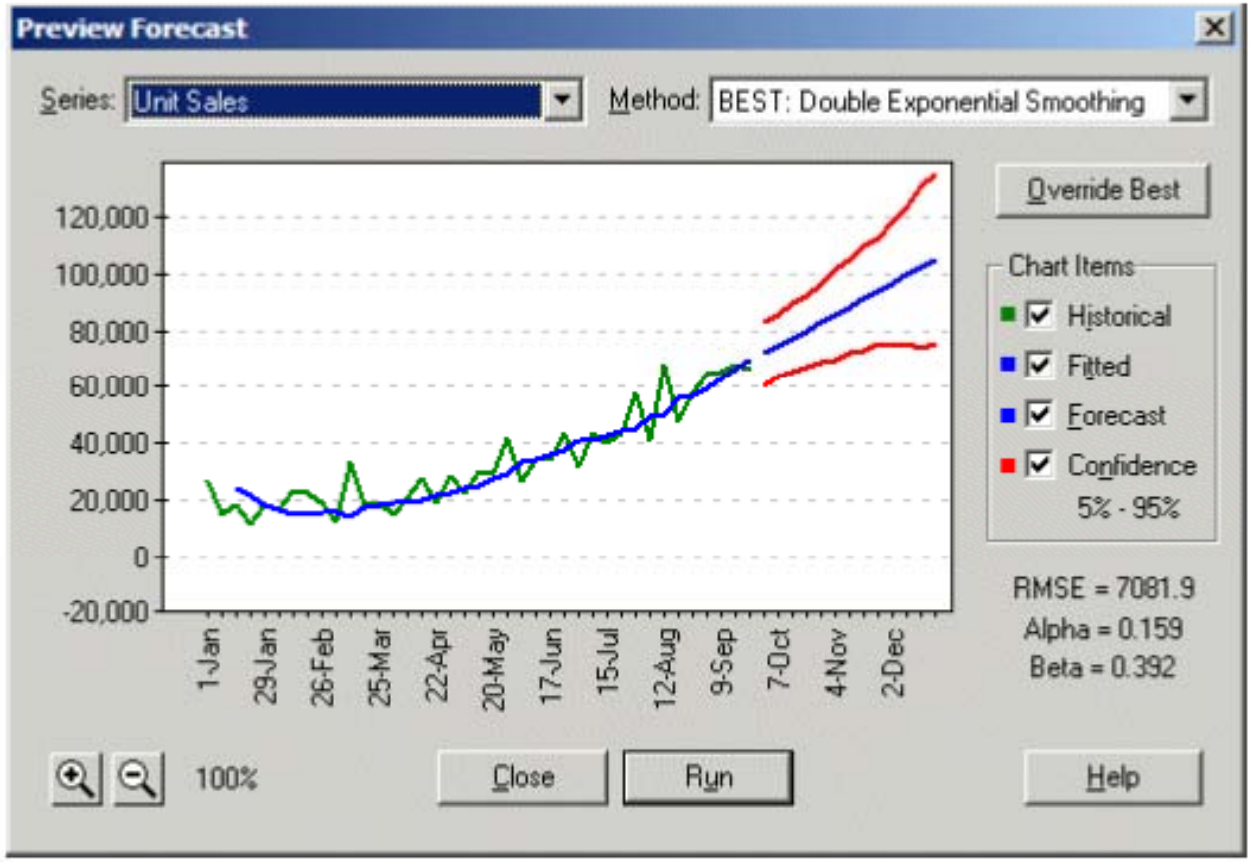
Shampoo Sales Tutorial

Figure 1–6 Preview Forecast dialog



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Shampoo Sales Tutorial

✓**13:** *In the Preview Forecast dialog, click the Method field. The field lists all the methods CB Predictor tried, in order from the best-fitting method (designated by the word "Best") to the worst-fitting method. CB Predictor calculates the forecasted values from the method that best fits the historical data. In this case, the method is Double Exponential Smoothing. The forecasted values appear as a blue line extending to the right of the historical data (green) and the fitted values (also in blue). Above and below the forecasted values is the confidence interval (in red), showing the 5th and 95th percentiles of the forecasted values.*

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Shampoo Sales Tutorial

✓ ***14:*** ***Click Run. The program pastes the forecasted values at the end of the historical data (in bold), extending the date series as well. The forecasted values were forecasted using the best method, as shown in the Preview dialog.***

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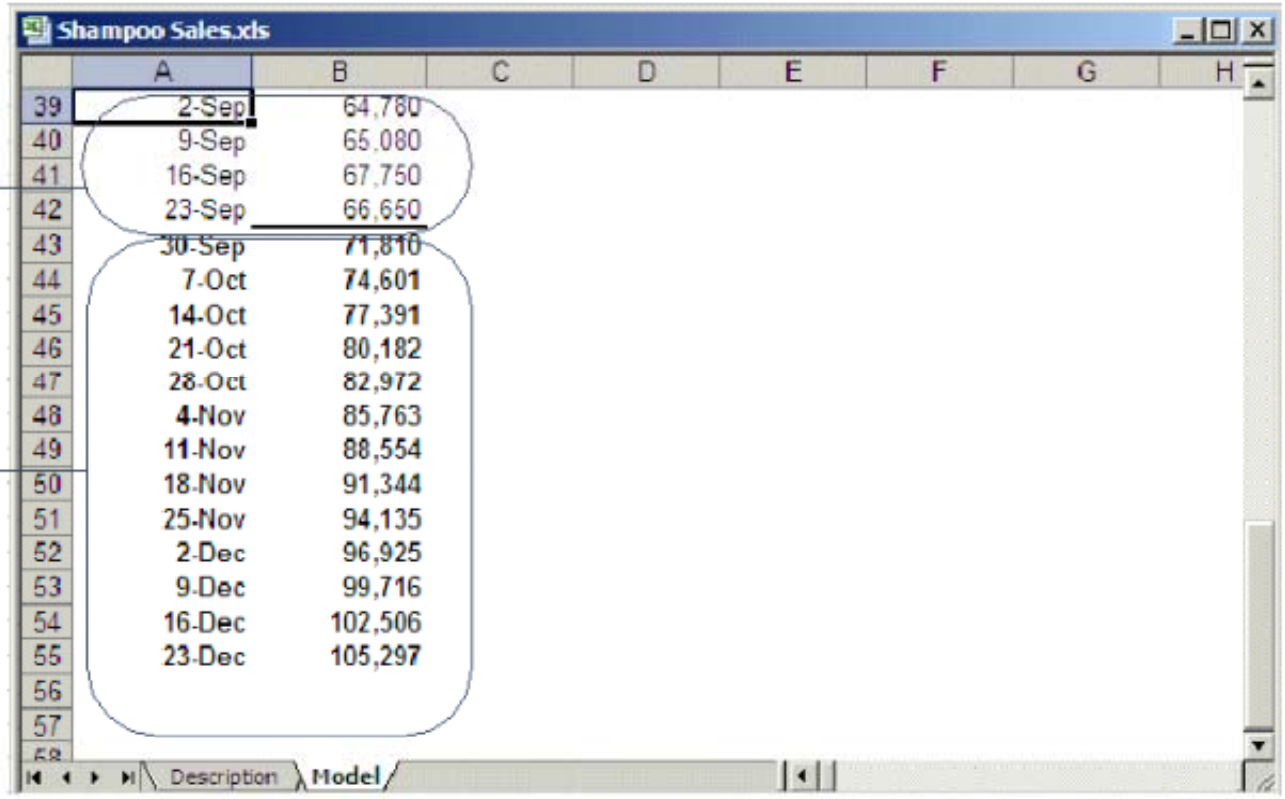
Shampoo Sales Tutorial

Figure 1–7 Pasted shampoo sales values

Historical data

Forecasted values



Decision: Recommendation for further funding on this product

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Thank you for the attention

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