



An Accredited Institution of the University of Westminster (UK)

# **LECTURE 9**

## **BASICS OF TIME SERIES FORECASTING**

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- to estimate the change of a value over time and graph the dynamics of the value
- to apply the time series analysis to forecasting a value
- to use the two forecasting models:
  - a) Additive
  - b) Multiplicative

# Components of time series graph

***Trend*** – the overall pattern of changes in a specific value over a long period of time (or an overall movement of the time series graph).

***Seasonal*** – regular patterns of variation over one year or less (or repetitive movements of the time series graph).

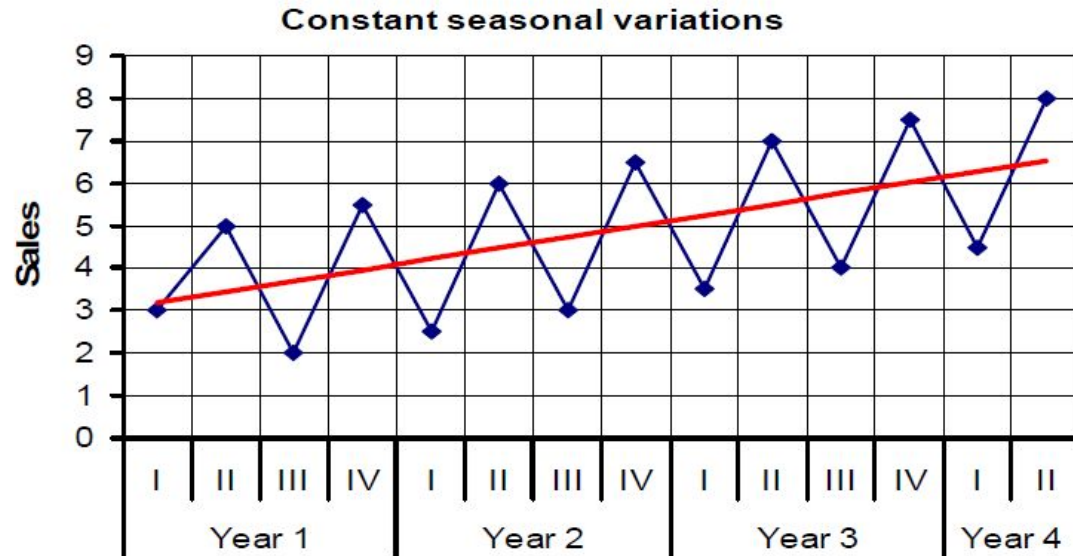
***Irregular*** – random changes that generally cannot be predicted (or random movements of the time series graph for periods less than a year).

***Cyclical*** – variations above or below the trend line for periods of longer than one year (or cyclical movements of the time series graph for periods of longer than one year)

# Additive vs Multiplicative Model

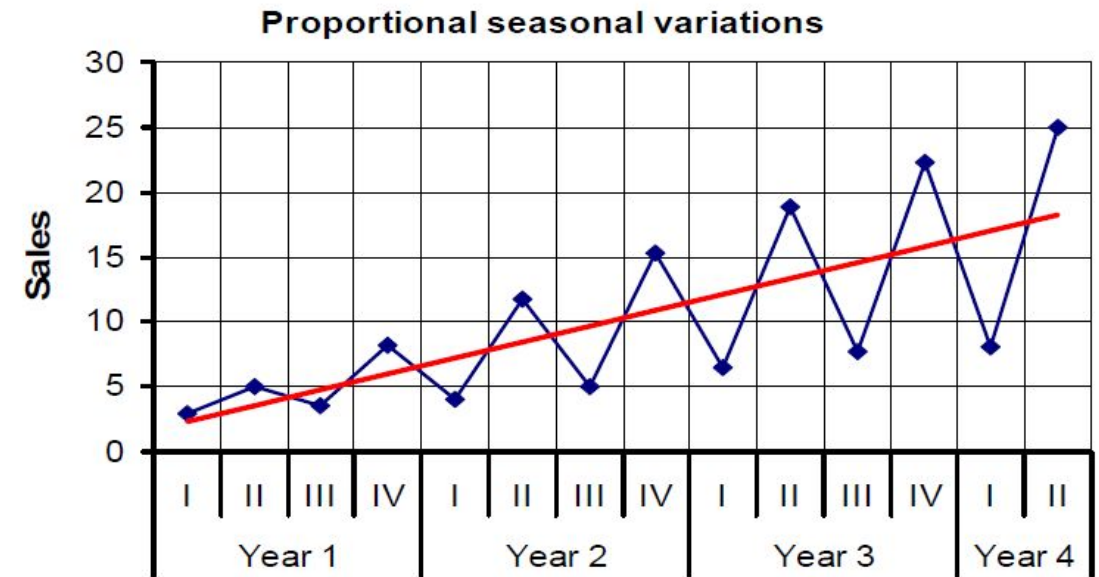
- Additive model

$Y_x = T_x + S_x$  where  $Y_x$  – actual figure in period x,  $T_x$  – trend in period x,  $S_x$  – seasonal variation in period x.



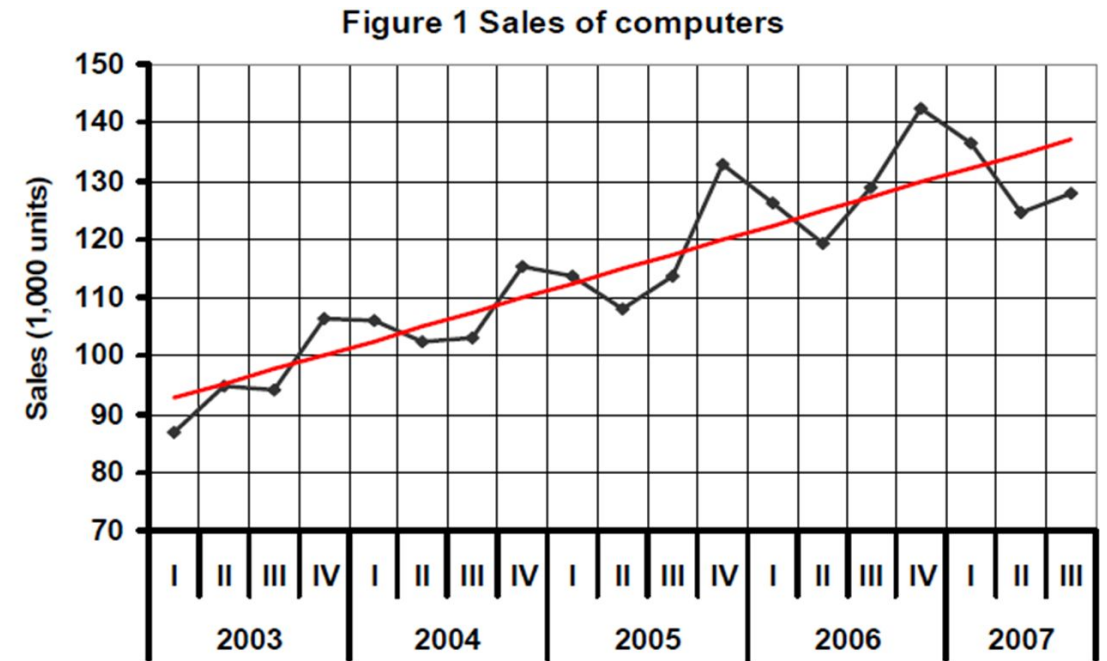
- Multiplicative model

$Y_x = T_x \cdot S_x$  where  $Y_x$  – actual figure in period x,  $T_x$  – trend in period x,  $S_x$  – seasonal variation in period x.



# Case 1: quarterly computer sales

Time		Sales	Time		Sales
2003	I	86.7		II	108.0
	II	94.9		III	113.5
	III	94.2		IV	132.9
	IV	106.5	2006	I	126.3
2004	I	105.9		II	119.4
	II	102.4		III	128.9
	III	103.1		IV	142.3
	IV	115.2	2007	I	136.4
2005	I	113.7		II	124.6
				III	127.9



# Additive model

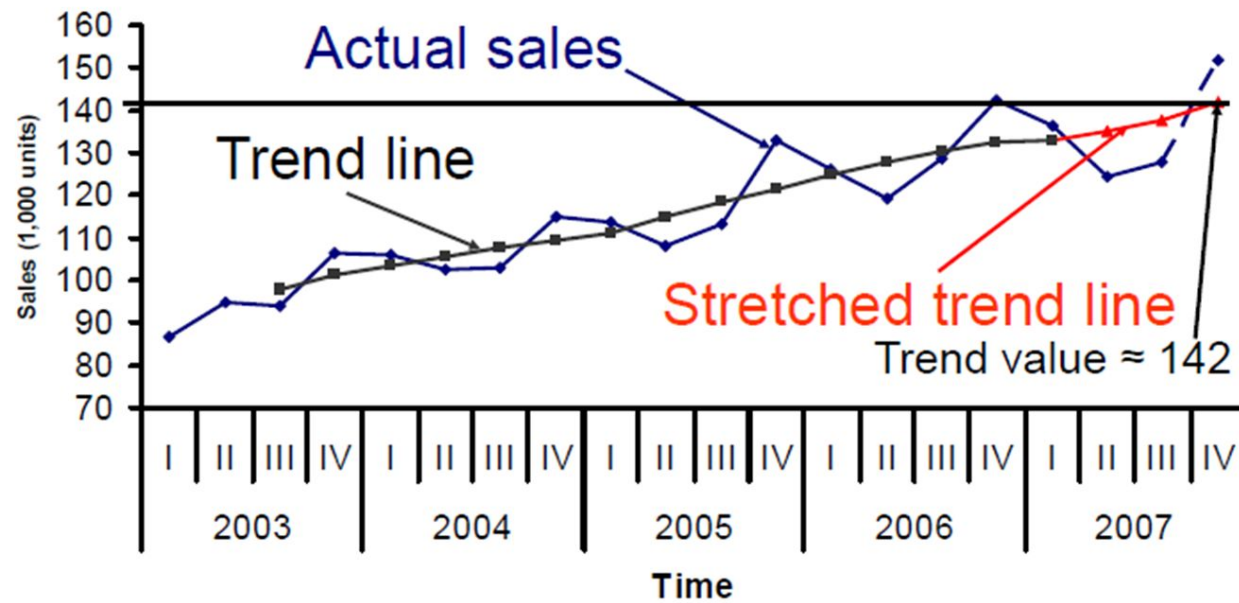
- Find 4-point moving average and start placing them from the mid of 2nd and 3rd place
- Calculate the Central Moving Average (Trend)
- Subtract trend (CMA) value from the actual value to find the deviations
- Compute average deviation for particular period
- Place the seasonal adjustments
- Obtain the difference between average deviations and the seasonal adjustments for the seasonal variations.
- To forecast, simply add the seasonal adjustment to forecasted Trend (CMA) value

Time		Sales ( $Y_x$ )	4-point MA	CMA, Trend
2003	I	86.7		
	II	94.9		
	III	94.2	95.58	97.98
	IV	106.5	100.38	101.31
2004	I	105.9	102.25	103.37
	II	102.4	104.48	105.57
	III	103.1	106.65	107.63
	IV	115.2	108.60	109.30
2005	I	113.7	110.00	111.30
	II	108.0	112.60	114.81

Time		Sales ( $Y_x$ )	4-point MA	CMA, Trend
	III	113.5	117.03	118.60
	IV	132.9	120.18	121.60
2006	I	126.3	123.03	124.95
	II	119.4	126.88	128.05
	III	128.9	129.23	130.49
	IV	142.3	131.75	132.40
2007	I	136.4	133.05	132.93
	II	124.6	132.80	
	III	127.9		



# Additive model



Time		Sales ( $Y_x$ )	Trend ( $T_x$ )	Dev from Trend $S_x = Y_x - T_x$	Time		Sales ( $Y_x$ )	Trend ( $T_x$ )	Dev from Trend $S_x = Y_x - T_x$
2003	I	86.7				III	113.5	118.6	- 5.1
	II	94.9				IV	132.9	121.6	11.3
	III	94.2	97.98	- 3.8	2006	I	126.3	124.95	1.4
	IV	106.5	101.31	5.2		II	119.4	128.05	- 8.7
2004	I	105.9	103.37	2.5		III	128.9	130.49	- 1.6
	II	102.4	105.57	- 3.2		IV	142.3	132.4	9.9
	III	103.1	107.63	- 4.5	2007	I	136.4	132.93	3.5
	IV	115.2	109.3	5.9		II	124.6		
2005	I	113.7	111.3	2.4		III	127.9		
	II	108.0	114.81	- 6.8					



# Additive model

	I	II	III	IV
2003			- 3.8	5.2
2004	2.5	- 3.2	- 4.5	5.9
2005	2.4	- 6.8	- 5.1	11.3
2006	1.4	- 8.7	- 1.6	9.9
2007	3.5			
Total	9.7	- 18.7	- 15.0	32.3
Average Deviation	2.43	- 6.23	- 3.75	8.08
Adjustment	0.13	0.13	0.13	0.13
Seasonal variation	2.3	- 6.36	- 3.88	7.95

- Trend line for the 4<sup>th</sup> quarter of 2007 indicates that the value approximately equals to **142**
- The seasonal variation for this quarter is **7.95**
- Thus, forecasted value equals to

$$Y_{2007\ IV} = T_{2007\ IV} + S_{2007\ IV} = \\ = 142 + 7.95 = 149.95 \approx 150$$

# Multiplicative model

- Find 4-point moving average and start placing them from the mid of 2<sup>nd</sup> and 3<sup>rd</sup> place
- Calculate the Central Moving Average (Trend)
- Divide the actual value to the trend (CMA) value to find the deviations
- Compute average deviation for particular period
- Place the seasonal adjustments
- Obtain the ratio between average deviations and the seasonal adjustments for the seasonal variations.

Time		Sales (Y <sub>t</sub> )	4-point MA	CMA, Trend
2003	I	86.7	95.58	
	II	94.9		
	III	94.2		97.98
	IV	106.5		101.31
2004	I	105.9	102.25	103.37
	II	102.4	104.48	105.57
	III	103.1	106.65	107.63
	IV	115.2	108.60	109.30
2005	I	113.7	110.00	111.30
	II	108.0	112.60	114.81

Time		Sales (Y <sub>t</sub> )	4-point MA	CMA, Trend
	III	113.5	117.03	118.60
	IV	132.9	120.18	121.60
2006	I	126.3	123.03	124.95
	II	119.4	126.88	128.05
	III	128.9	129.23	130.49
	IV	142.3	131.75	132.40
2007	I	136.4	133.05	132.93
	II	124.6	132.80	
	III	127.9		

To forecast, simply find the product of the seasonal adjustment and forecasted Trend (CMA) value

# Multiplicative model

Time		Sales (Y <sub>x</sub> )	Trend (T <sub>x</sub> )	Dev from Trend (S <sub>x</sub> =Y <sub>x</sub> /T <sub>x</sub> )
2003	I	86.7		
	II	94.9		
	III	94.2	97.98	0.96
	IV	106.5	101.31	1.05
2004	I	105.9	103.36	1.02
	II	102.4	105.56	0.97
	III	103.1	107.63	0.96
	IV	115.2	109.30	1.05
2005	I	113.7	111.30	1.02
	II	108.0	114.81	0.94

Time		Sales (Y <sub>x</sub> )	Trend (T <sub>x</sub> )	Dev from Trend (S <sub>x</sub> =Y <sub>x</sub> /T <sub>x</sub> )
	III	113.5	118.60	0.96
	IV	132.9	121.60	1.09
2006	I	126.3	124.95	1.01
	II	119.4	128.05	0.93
	III	128.9	130.49	0.99
	IV	142.3	132.40	1.07
2007	I	136.4	132.93	1.03
	II	124.6		
	III	127.9		

	I	II	III	IV
2003			0.96	1.05
2004	1.02	0.97	0.96	1.05
2005	1.02	0.94	0.96	1.09
2006	1.01	0.93	0.99	1.07
2007	1.03			
Total	4.08	2.84	3.87	4.26
Average deviation	1.02	0.95	0.97	1.07
Adjustment	1	1	1	1
Seasonal variation	1.02	0.95	0.97	1.07

# Multiplicative model

- Trend line for the 4<sup>th</sup> quarter of 2007 indicates that the value approximately equals to **142**
- The seasonal variation for this quarter is **1.07**
- Thus, forecasted value equals to

$$Y_{2007 IV} = T_{2007 IV} \cdot S_{2007 IV} =$$
$$= 142 \cdot 1.07 = 151.9 \approx 152$$

	I	II	III	IV
2003			0.96	1.05
2004	1.02	0.97	0.96	1.05
2005	1.02	0.94	0.96	1.09
2006	1.01	0.93	0.99	1.07
2007	1.03			
Total	4.08	2.84	3.87	4.26
Average deviation	1.02	0.95	0.97	1.07
Adjustment	1	1	1	1
Seasonal variation	1.02	0.95	0.97	1.07

Today, you learned

- Graphical display of the change of a value over time
- Time series analysis
- Two time series models: *additive* and *multiplicative*
- Forecasting future value with the suitable model

Jon Curwin and Roger Slater. “Quantitative Methods for Business Decisions,” Ch 17.