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#### 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

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• 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



#### Case 1: quarterly computer sales



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



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## 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

Ti	me	Sales (Y <sub>x</sub> )	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	Ι	105.9	102.25	103.37	
	Π	102.4	104.48	105.57	
	Ш	103.1	100.05	107.63	
	IV	115.2	110.00	109.30	
2005	005 I	113.7	112.60	111.30	
	II	108.0	112.00	114.81	

Ti	me	Sales (Y <sub>x</sub> )	4-point MA	CMA, Trend	
	III	113.5	117.03	118.60	
	IV	132.9	120.18	121.60	
2006	Ι	126.3	123.03	124.95	
	II	<u>119.4</u>	126.88	128.05	
	III	128.9	129.25	130.49	
	IV	142.3	133.05	132.40	
2007	Ι	136.4	132.80	132.93	
	II	124.6			
	III	127.9			

#### **Additive 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>	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	Ι	86.7				III	113.5	118.6	- 5.1
	Π	94.9				IV	132.9	121.6	11.3
	III	94.2	97.98	- 3.8	2006	Ι	126.3	124.95	1.4
	IV	106.5	101.31	5.2		II	119.4	128.05	- 8.7
2004	Ι	105.9	103.37	2.5		III	128.9	130.49	- 1.6
	Π	102.4	105.57	- 3.2		IV	142.3	132.4	9.9
	III	103.1	107.63	- 4.5	2007	Ι	136.4	132.93	3.5
	IV	115.2	109.3	5.9		Π	124.6		
2005	T	113.2	111.3	2.4		III	127.9		
2005	1	115.7	111.5	2.4			•		·•
	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 ≈ 150



### **Multiplicative model**



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- 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.

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

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Ti	me	Sales (Y <sub>x</sub> )	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	Ι	105.9	102.25 104.48	103.37
	II	102.4		105.57
	III	103.1	100.05	107.63
	IV	115.2	110.00	109.30
2005	Ι	113.7	112.60	111.30
	II	108.0	112.00	114.81

Ti	me	Sales (Y <sub>x</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 III	119.4 128.9	126.88 129.23	128.05
				130.49
	IV	142.3	133.05	132.40
2007	2007 I		132.80	132.93
	II	124.6		
	III	127.9		



			Sales	Trend	Dev from			Sales	Trend	Dev from			I	II	III	IV
	Ti	me	(Y <sub>x</sub> )	(T <sub>x</sub> )	Trend $(S_r=Y_r/T_r)$	Ti	Time $(Y_x)$		(T <sub>x</sub> )	$\frac{\text{Trend}}{(S_r = Y_r/T_r)}$		2003			0.96	1.05
t	2003	Ι	86.7				III	113.5	118.60	0.96		2004	1.02	0.97	0.96	1.05
t		II	94.9				IV	132.9	121.60	1.09		2005	1.02	0.94	0.96	1.09
t		III	94.2	97.98	0.96	2006	I	126.3	124.95	1.01		2006	1.01	0.93	0.99	1.07
t		IV	106.5	101.31	1.05		II	119.4	128.05	0.93		2007	1.03			
	2004	I	105.9	103.36	1.02		III	128.9	130.49	0.99		Total	4.08	2.84	3.87	4.26
t		п	102.4	105.56	0.97		IV	142.3	132.40	1.07	Ī	Average deviation	1.02	0.95	0.97	1.07
ł		ш	103.1	107.63	0.96	2007	Ι	136.4	132.93	1.03		Adjustment	1	1	1	1
t		IV	115.2	109.30	1.05		II	124.6				Seasonal variation	1.02	0.95	0.97	1.07
t	2005	I	113.7	111.30	1.02		III	127.9			L			1		I
ł		II	108.0	114.81	0.94											

#### **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



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# Jon Curwin and Roger Slater. "Quantitative Methods for Business Decisions," Ch 17.