Measuring seasonal changes
قياس التغيرات الموسمية

2- Ratio method to the general trend طريقة النسبة الى الاتجاه العام

The method of ratio to the general trend is one of the most important and most accurate methods used in estimating seasonal changes (quarterly or monthly). This method is superior to other methods because it helps us to rid the observations of the time series of the phenomenon (y) from the effect of the general trend first and to the possibility of finding predictive values for the phenomenon (y) in the future based on the adjusted seasonal values (%S) second. The steps of this method are summarized as follows:

تعد طريقة النسبة الى الاتجاه العام من اهم الطرق المستخدمة في تقدير التغيرات الموسمية (الفصلية او الشهرية) وادقها وتتفوق هذه الطريقة على الطرق الاخرى لأنها تساعدنا على تخليص مشاهدات السلسلة الزمنية للظاهرة (y) من اثر الاتجاه العام اولاً والى امكانية ايجاد القيم التنبؤية للظاهرة (y) في المستقبل اعتماداً على القيم الموسمية المعدلة (S%) ثانياً. وتتلخص خطوات هذه الطريقة بمايلي:

1- Estimate the general trend line equation using the least squares method, and ensure that the sum of the time series is not equal to zero.

تقدير معادلة خط الاتجاه العام باستخدام طريقة المربعات الصغرى وان مجموع تسلسل الزمن لايساوي صفراً.

2- Calculate the trend values of the phenomenon (ŷ) based on the general trend line equation.

حساب القيم الاتجاهية للظاهرة (ŷ) اعتماداً على معادلة خط الاتجاه العام.

3- Remove the observations of the phenomenon (y) from the effect of the general trend according to the following formula:

تخليص مشاهدات الظاهرة (y) من اثر الاتجاه العام وفقاً للصيغة الاتية:

$$y^* = \frac{y}{\hat{y} = T} \times 100\%$$

4- Separating seasonal changes from cyclical and random changes. This is done by finding the modified seasonal indicators (%S) according to the following law:

فصل التغيرات الموسمية عن التغيرات الدورية والعشوائية ويتم ذلك من خلال ايجاد المؤشرات الموسمية المعدلة (S%) وفقاً للقانون الاتي:

$$S\% = \frac{\bar{Q}_i}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100$$

5- Finding the predictive values of the class through the following law:

ايجاد القيم التنبؤية للافصل من خلال القانون الاتي:

$$\hat{Q} = \frac{T * S}{100}$$

6- The effect of the season is removed from the observations of the phenomenon (y) according to the following formula: ازالة تأثير الموسم من المشاهدات وفق الصيغة الاتية

$$y^{**} = \frac{y}{S\%} \times 100\%$$

Example: The following data represents the quarterly sales value of a commercial establishment during the period 2002-2004.

Required:

1. Find the equation of the general trend line using the least squares method.
2. Exclude the effect of the general trend from the observations of the phenomenon.
3. Calculate the seasonality index (%S) using the ratio to the general trend method.
4. Remove the effect of the season (seasonal variation) from the observations of the phenomenon (y).
5. Predict the quarterly sales values for the year 2005.

Years	2002				2003				2004			
seasons	Q_1	Q_2	Q_3	Q_4	Q_1	Q_2	Q_3	Q_4	Q_1	Q_2	Q_3	Q_4
sales	12	14	16	10	20	10	12	18	16	18	20	10

Sol:

1- Finding the equation of the general trend line.

Years	seasons	y	t	t*y	t^2	$\hat{y}_i = 13.045 + 0.25t_i$	$y^* = \frac{y}{\hat{y}} \times 100$
2002	Q_1	12	1	12	1	13.295	(12/13.295)×100 =90.26
	Q_2	14	2	28	4	13.545	(14/13.545)×100 =103.36
	Q_3	16	3	48	9	13.795	(16/13.795)×100 =115.98
	Q_4	10	4	40	16	14.045	(10/14.045)×100 =71.20
2003	Q_1	20	5	100	25	14.295	(20/14.295)×100 =139.91
	Q_2	10	6	60	36	14.545	(10/14.545)×100 =68.75
	Q_3	12	7	84	49	14.795	(12/14.795)×100 =81.11
	Q_4	18	8	144	64	15.045	(18/15.045)×100 =119.64
2004	Q_1	16	9	144	81	15.295	(16/15.295)×100 =104.61

	Q_2	18	10	180	100	15.545	(18/15.545)×100 =115.79
	Q_3	20	11	220	121	15.795	(20/15.795)×100 =126.62
	Q_4	10	12	120	144	16.045	(10/16.045)×100 =62.32
sum		*176*	**78**	**1180**	**650**		

$$\hat{y} = \hat{a} + \hat{b}t$$

$$\hat{b} = \frac{n\sum_{i=1}^{n} y_i t_i - \sum_{i=1}^{n} y_i \sum_{i=1}^{n} t_i}{n\sum_{i=1}^{n} t_i^2 - \left(\sum_{i=1}^{n} t_i\right)^2} = \frac{12 \times (1180) - (176)(78)}{12 \times (650) - (78)^2} = 0.25$$

$$\hat{a} = \frac{\sum_{i=1}^{n} y_i}{n} - b\frac{\sum_{i=1}^{n} t_i}{n} = \frac{176}{12} - 0.25\frac{78}{12} = 14.67 - (0.25)(6.5) = 13.045$$

$$\hat{y}_i = 13.045 + 0.25t_i$$

2- The effect of the general trend is excluded from the observations of the phenomenon by first finding the directional values of the phenomenon ($\hat{y}_i$) by substituting the order of the seasons ($t_i = 1,2,3,4,\ldots,12$) in the estimated general trend equation, then calculating the observations of the phenomenon stripped of the effect of the general trend according to the following formula:

$$y^* = \frac{\mathbf{y}}{\hat{\mathbf{y}}} \times \mathbf{100}$$

3- Calculating the adjusted seasonal indicators for the seasons. This is done by first organizing the percentages of sales values stripped of the effect of the general trend in a second table in order to be able to calculate the quarterly averages.

Years/Seasons	**Q_1**	**Q_2**	**Q_3**	**Q_4**
2002	90.26	103.36	115.98	71.20
2003	139.91	68.75	81.11	119.64
2004	104.61	115.79	126.62	62.32
Sum of Seasons	334.78	287.90	323.71	253.16
$\bar{Q}_i$	111.59	95.97	107.90	84.39
$\sum_{i=1}^{4} \bar{Q}_i$	399.85			
	111.63 %	96.01 %	107.94 %	84.42 %

Then calculate the seasonal indicators according to the following relationship:

$$S\% = \frac{\bar{Q}_i}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100$$

$$S_1\% = \frac{\bar{Q}_1}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{111.59}{399.85} \times 4 \times 100 = 111.63\%$$

$$S_2\% = \frac{\bar{Q}_2}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{95.97}{399.85} \times 4 \times 100 = 96.01\%$$

$$S_3\% = \frac{\bar{Q}_3}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{107.90}{399.85} \times 4 \times 100 = 107.94\%$$

$$S_4\% = \frac{\bar{Q}_4}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{84.39}{399.85} \times 4 \times 100 = 84.42\%$$

4- The season effect is removed from the observation as follows:

Years	seasons	y	%S	$y^{**} = \frac{\mathbf{y}}{S\%} \times 100$
2002	Q_1	12	111.63	(12/111.63)×100 =11
	Q_2	14	96.01	(14/96.01)×100 =15
	Q_3	16	107.94	(16/107.94)×100 =15
	Q_4	10	84.42	(10/84.42)×100 =12
2003	Q_1	20	111.63	(20/111.63)×100 =18
	Q_2	10	96.01	(10/96.01)×100 =10
	Q_3	12	107.94	(12/109.03)×100 =11
	Q_4	18	84.42	(18/84.42)×100 =21
2004	Q_1	16	111.63	(16/111.63)×100 =15
	Q_2	18	96.01	(18/96.01)×100 =19
	Q_3	20	107.94	(20/107.94)×100 =18
	Q_4	10	84.42	(10/84.42)×100 =12

5- Predicting sales values for the year 2005 is obtained according to the following relationship:

$$\hat{Q} = \frac{\mathbf{T \times S}}{\mathbf{100}}$$

Years	seasons	t	$T = \hat{y}_i = 13.045 + 0.25t_i$	%S	$\hat{Q} = \frac{\mathbf{T \times S}}{\mathbf{100}}$
2005	Q_1	13	16.295	111.63	(16.295×111.63)/100 =18
	Q_2	14	16.545	96.01	(16.545×96.01)/100 =16
	Q_3	15	16.795	107.94	(16.795×107.94)/100 =18
	Q_4	16	17.045	84.42	(17.045×84.42)/100 =14