Measuring Random Variations
قياس التغيرات العشوائية

Random (irregular) variations are defined as variations that cannot be controlled or predicted for future periods.

This type of variation is one of the simplest factors affecting a time series, as it is an error that may occur as a result of minor, incidental changes whose causes cannot be controlled.

تعرف التغيرات العشوائية (غير المنتظمة) بانها التغيرات التي لا يمكن التحكم بها والسيطرة عليها وعدم امكانية التنبؤ بها لفترات زمنية مستقبلية. يعد هذا النوع من التغيرات من ابسط العوامل المؤثرة على السلسلة الزمنية كونها أخطاءً قد تحدث نتيجة تغيرات عرضية طفيفة لا يمكن التحكم في اسباب حدوثها.

To estimate irregular changes, the rest of the time series components, represented by directional, seasonal, and periodic changes, must be estimated. To estimate irregular (random) variations and separate them from the other components of the time series, follow the following steps:

لتقدير التغيرات غير المنتظمة ينبغي تقدير بقية مكونات السلسلة الزمنية المتمثلة بالتغيرات الاتجاهية والموسمية والدورية . ولتقدير التغيرات غير المنتظمة (العشوائية) وفصلها عن بقية مركبات السلسلة الزمنية الاخرى يتبع الخطوات الاتية:

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- Finding the adjusted seasonal indicators (%S) using the ratio method to the general trend according to the following law:

ايجاد المؤشرات الموسمية المعدلة ($\%S$) باستخدام طريقة النسبة الى الاتجاه العام وفقاً للقانون الاتي:

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

5− Finding the periodic ratios according to the following law:

ايجاد النسب الدورية وفق القانون الاتي:

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

6- Finding irregular ratios according to the following law:

ايجاد النسب غير منتظمة وفق القانون الاتي:

$$R\% = \frac{y}{T * S\% * c\%} \times 100$$

7- Extricating observations of the phenomenon (y) from the effect of random changes according to the following formula:

تخليص مشاهدات الظاهرة (y) من اثر التغيرات العشوائية وفقاً للصيغة الاتية:

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

Example: The following data represents the production quantity (in thousands of tons) of a particular crop during the period 2000-2002.

Requirements:

1- Find the equation of the general trend line using the least squares method.
2- Excluding the effect of the general trend from observations of the phenomenon.
3- Calculate seasonal indices (%S) using the ratio to the general trend method.
4- Calculate the periodic ratios of production quantities for the above period.
5- Calculate the irregular ratios of production quantities for the above period
6- Removing the effect of random changes from observations of the phenomenon (y).

Years	2000				2001				2002			
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
production	20	26	18	21	24	30	29	28	31	28	20	25

Sol:

1- Finding the equation of the general trend line.

Years	seasons	y	t	t*y	t^2	$\hat{y}_i = 22.01 + 0.46t_i$	$y^* = \frac{y}{\hat{y}} \times 100$
2002	Q_1	20	1	20	1	22.47	(20/22.47)×100 =89.01
	Q_2	26	2	52	4	22.93	(26/22.93)×100 =113.39
	Q_3	18	3	54	9	23.39	(18/23.39)×100 =76.96
	Q_4	21	4	84	16	23.85	(21/23.85)×100 =88.05
2003	Q_1	24	5	120	25	24.31	(24/24.31)×100 =98.72
	Q_2	30	6	180	36	24.77	(30/24.77)×100 =121.11

	Q_3	29	7	203	49	25.23	(29/25.23)×100 =114.94
	Q_4	28	8	224	64	25.69	(28/25.69)×100 =108.99
2004	**Q_1**	31	9	279	81	26.15	(31/26.15)×100 =118.55
	Q_2	28	10	280	100	26.61	(28/26.61)×100 =105.22
	Q_3	20	11	220	121	27.07	(20/27.07)×100 =73.88
	Q_4	25	12	300	144	27.53	(25/27.53)×100 =90.81
sum		**300**	**78**	**2016**	**650**		

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

$$\hat{b} = \frac{n\sum_{i=1}^{n} y_i t_i - \sum_{i=1}^{n} y_i \sum_{i=1}^{n} t_i}{n\sum_{i=1}^{n} t_i^2 - \left(\sum_{i=1}^{n} t_i\right)^2} = \frac{12 \times (2016) - (300)(78)}{12 \times (650) - (78)^2} = 0.46$$

$$\hat{a} = \frac{\sum_{i=1}^{n} y_i}{n} - b\frac{\sum_{i=1}^{n} t_i}{n} = \frac{300}{12} - 0.46\frac{78}{12} = 25 - (0.46)(6.5) = 22.01$$

$$\hat{y}_i = 22.01 + 0.46t_i$$

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 ($t_i = 1,2,3,4,\dots,12$) 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:

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

3- Calculating seasonal indicators adjusted for the seasons according to the method of ratio to the general trend. This is done by first organizing the ratios of production values devoid of the effect of the general trend in a second table in order to be able to calculate averages for the seasons.

Years/Seasons	**Q_1**	**Q_2**	**Q_3**	**Q_4**
2002	89.01	113.39	76.96	88.05
2003	98.72	121.11	114.94	108.99
2004	118.55	105.22	73.88	90.81
Sum of Seasons	306.28	339.72	265.78	287.85
$\bar{Q}_i$	102.09	113.24	88.59	95.95
$\sum_{i=1}^{4} \bar{Q}_i$	399.87			

	102.12%	113.28%	88.62%	95.98%

Then calculate the seasonal indicators according to the following relationship:

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

$$S_1\% = \frac{\bar{Q}_1}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{102.09}{399.87} \times 4 \times 100 = 102.12\%$$

$$S_2\% = \frac{\bar{Q}_2}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{113.24}{399.87} \times 4 \times 100 = 113.28\%$$

$$S_3\% = \frac{\bar{Q}_3}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{88.59}{399.87} \times 4 \times 100 = 88.62\%$$

$$S_4\% = \frac{\bar{Q}_4}{\sum_{i=1}^{4} \bar{Q}_i} \times 4 \times 100 = \frac{95.95}{399.87} \times 4 \times 100 = 95.98\%$$

4- The periodic ratios are found from the observations according to the following law:

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

Years	seasons	y	y^*	%S	$C = \frac{y^*}{S\%} \times 100$
2000	Q_1	20	89.01	102.12	(89.01/102.12)×100=87.16
	Q_2	26	113.39	113.28	(113.39/113.28)×100=100.10
	Q_3	18	76.96	88.62	(76.96/88.62)×100 =86.84
	Q_4	21	88.05	95.98	(88.05/95.98)×100 =91.74
2001	Q_1	24	98.72	102.12	(98.72/102.12)×100 =96.67
	Q_2	30	121.11	113.28	(121.11/113.28)×100=106.91
	Q_3	29	114.94	88.62	(114.94/88.62)×100=129.70
	Q_4	28	108.99	95.98	(108.99/95.98)×100=113.55
2002	Q_1	31	118.55	102.12	(118.55/102.12)×100=116.09
	Q_2	28	105.22	113.28	(105.22/113.28)×100=92.88
	Q_3	20	73.88	88.62	(73.88/88.62)×100 =83.37
	Q_4	25	90.81	95.98	(90.81/95.98)×100 =94.61

5- The periodic ratios are found from the observations according to the following law:

$$R\% = \frac{y}{T * S\% * c\%} \times 100$$

The random proportions are calculated as follows:

For the first quarter of the year 2000, it is:

$$R_1\% = \frac{20}{22.47 * \frac{102.12}{100} * \frac{87.16}{100}} \times 100 = 100$$

For the second quarter of 2000 it is

$$R_2\% = \frac{26}{22.93 * \frac{113.28}{100} * \frac{100.10}{100}} \times 100 = 99.996$$

Thus, the remaining values for the random proportions are calculated.

The effect of random variations is removed according to the following law:

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

Years	seasons	y	T	%S	$C\%$	$R\%$	y^{****}
2000	Q_1	20	22.47	102.12	87.16	100	(20/100)×100 =20
	Q_2	26	22.93	113.28	100.10	99.996	(26/99.996)×100 =26
	Q_3	18	23.39	88.62	86.84	99.998	(18/99.998)×100 =18
	Q_4	21	23.85	95.98	91.74	99.998	(21/99.998)×100 =21
2001	Q_1	24	24.31	102.12	96.67	100.005	(24/100.005)×100 =24
	Q_2	30	24.77	113.28	106.91	100.005	(30/100.005)×100 =30
	Q_3	29	25.23	88.62	129.70	100.002	(29/100.002)×100 =29
	Q_4	28	25.69	95.98	113.55	100.006	(28/100.006)×100 =28
2002	Q_1	31	26.15	102.12	116.09	99.996	(31/99.996)×100 =31
	Q_2	28	26.61	113.28	92.88	100.009	(28/100.009)×100 =28
	Q_3	20	27.07	88.62	83.37	100	(20/100)×100 =20
	Q_4	25	27.53	95.98	94.61	100.004	(25/100.004)×100 =25