Chapter 3 Seasonal Adjustment

Seasonal adjustment is a procedure that removes the seasonal pattern from a time series. The result, called a seasonally-adjusted time series, should contain only trend and noise, which simplifies the forecasting problem. MULTIMON assumes that seasonal fluctuations are proportional to the value of the data. Therefore, as a trend grows, the range of seasonal fluctuation from peak to trough increases. This type of seasonality is called multiplicative. In contrast, the ADDITMON model assumes additive seasonality, in which seasonal fluctuations are constant in value, regardless of trend.

How do you know which model to use? ADDITMON is better for noisy data, such as time series of inventory demands, because it is more resistant to outliers. When the data contain zeroes, ADDITMON is the only reasonable choice. In highly aggregated data, such as economic time series, multiplicative seasonality is common, making MULTIMON the best option In cases of doubt, run both models and choose the one that produces the smallest variance.

3.1 Seasonal adjustment of monthly data (MULTIMON)

The Hill Country Vineyards of Fredericksburg, Texas, uses the MULTIMON worksheet in Figure 3-1 to perform multiplicative seasonal adjustment. To illustrate, consider champagne sales, which are highly seasonal, with a peak around the holidays at the end of the year. The first step in seasonal adjustment in Figure 3-1 is to compute a 12-month moving average of the data in column D. The first moving average, covering January through December, is always placed next to month 7. The second moving average, for February through January, is placed opposite month 8, and so on. This procedure means that there will not be a moving average for the first 6 or the last 5 months of the data.

The second step is to use the moving averages to compute seasonal indices. If we divide each data point by its moving average, the result is a preliminary seasonal index. Ratios are computed in column E: Each ratio is simply the actual sales in column C divided by the moving average in column D. The ratios for the same month in each year vary somewhat, so they are summed in column F and averaged in column H. The average ratios can be interpreted as follows. Sales in January are predicted to be 73.6% of average monthly sales for the year. Sales in December are predicted to be 207.3% of average. For this interpretation to make sense, the average ratios must sum to 12 since there are 12 months in the year. The average ratios actually sum to 12.124 because rounding is unavoidable. Therefore, formulas in column I "normalize" the ratios to sum to 12. In column J, the set of monthly ratios is repeated in each year. Finally, each actual data point in column C is divided by the seasonal index applicable to that month to obtain the adjusted data in column K.

To summarize how multiplicative seasonal indices are used in the forecasting models:

Original data / Multiplicative seasonal index = Deseasonalized data **(3-1)**

Deseasonalized data x Multiplicative seasonal index = Original data **(3-2)**

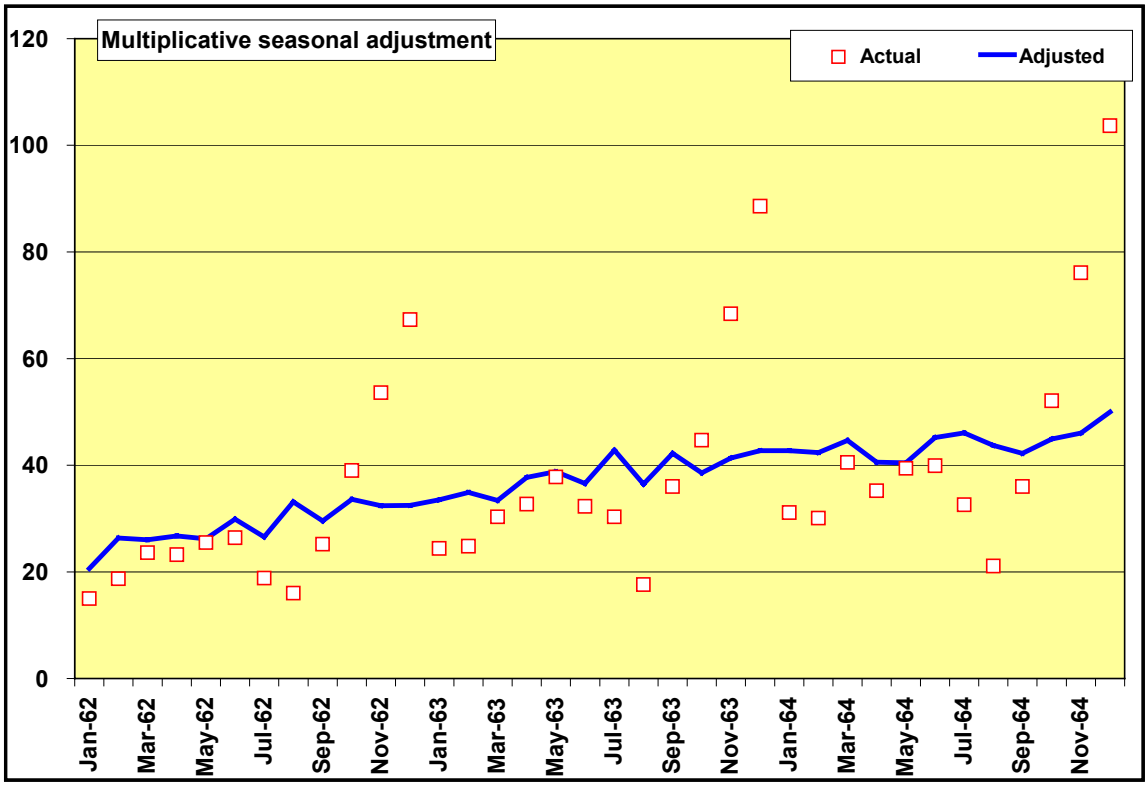
If seasonal adjustment makes sense for a time series, the variance of the adjusted data will be smaller than the variance of the original data. Variances are computed in I16..I17. Coefficients of variation (standard deviation / mean) are also computed. In the champagne series, seasonal adjustment makes a tremendous reduction in both variance and coefficient of variation. This makes the seasonally-adjusted data much easier to forecast than the original data.

Original and seasonally-adjusted data are plotted in Figure 3-2. In the adjusted data, there may be an erratic trend at work, although there is very little growth over the last year of adjusted data. This suggests use of simple exponential smoothing (Chapter 6) as a forecasting model for the seasonally-adjusted data.

Figure 3-1

	A	B	C	D	E	F	G	H	I	J	K
1	**MULTIMON.XLS**										
2	**Multiplicative seasonal adjustment**										
3	**Hill Country Champagne Sales**										
4											
5	**1st moving average at month**			7					**Actual**	**Adj.**	
6	**Last moving average at month**			31			**Variances**		418.2	52.5	
7	**Total number of data**			36			**Coeff. of variation**		54.2%	19.6%	
8											
9											
10		**Month**	**Actual**	**Moving**		**Sum of**	**# of**	**Avg.**	**Final**	**Monthly**	**Adj.**
11		**& year**	**data**	**avg.**	**Ratio**	**ratios**	**ratios**	**ratio**	**index**	**index**	**data**
12	1	**Jan-62**	**15.0**	0.0	0.00	1.47	2	0.736	0.728	0.728	20.60
13	2	**Feb-62**	**18.7**	0.0	0.00	1.44	2	0.718	0.711	0.711	26.32
14	3	**Mar-62**	**23.6**	0.0	0.00	1.83	2	0.916	0.907	0.907	26.02
15	4	**Apr-62**	**23.2**	0.0	0.00	1.75	2	0.877	0.868	0.868	26.74
16	5	**May-62**	**25.5**	0.0	0.00	1.97	2	0.984	0.974	0.974	26.18
17	6	**Jun-62**	**26.4**	0.0	0.00	1.78	2	0.892	0.883	0.883	29.90
18	7	**Jul-62**	**18.8**	29.4	0.64	2.14	3	0.715	0.708	0.708	26.57
19	8	**Aug-62**	**16.0**	30.1	0.53	0.98	2	0.488	0.483	0.483	33.13
20	9	**Sep-62**	**25.2**	30.7	0.82	1.72	2	0.861	0.852	0.852	29.57
21	10	**Oct-62**	**39.0**	31.2	1.25	2.34	2	1.172	1.160	1.160	33.62
22	11	**Nov-62**	**53.6**	32.0	1.68	3.34	2	1.671	1.653	1.653	32.42
23	12	**Dec-62**	**67.3**	33.0	2.04	4.19	2	2.095	2.073	2.073	32.46
24	13	**Jan-63**	**24.4**	33.5	0.73		Sum	12.124	12.000	0.728	33.50
25	14	**Feb-63**	**24.8**	34.5	0.72					0.711	34.90
26	15	**Mar-63**	**30.3**	34.6	0.88					0.907	33.40
27	16	**Apr-63**	**32.7**	35.5	0.92					0.868	37.69
28	17	**May-63**	**37.8**	36.0	1.05					0.974	38.80
29	18	**Jun-63**	**32.3**	37.2	0.87					0.883	36.59
30	19	**Jul-63**	**30.3**	39.0	0.78					0.708	42.82
31	20	**Aug-63**	**17.6**	39.6	0.45					0.483	36.45
32	21	**Sep-63**	**36.0**	40.0	0.90					0.852	42.24
33	22	**Oct-63**	**44.7**	40.8	1.09					1.160	38.53
34	23	**Nov-63**	**68.4**	41.1	1.67					1.653	41.37
35	24	**Dec-63**	**88.6**	41.2	2.15					2.073	42.74
36	25	**Jan-64**	**31.1**	41.8	0.74					0.728	42.70
37	26	**Feb-64**	**30.1**	42.0	0.72					0.711	42.36
38	27	**Mar-64**	**40.5**	42.3	0.96					0.907	44.65
39	28	**Apr-64**	**35.2**	42.3	0.83					0.868	40.57
40	29	**May-64**	**39.4**	42.9	0.92					0.974	40.44
41	30	**Jun-64**	**39.9**	43.6	0.92					0.883	45.20
42	31	**Jul-64**	**32.6**	44.8	0.73					0.708	46.07
43	32	**Aug-64**	**21.1**	0.0	0.00					0.483	43.69
44	33	**Sep-64**	**36.0**	0.0	0.00					0.852	42.24
45	34	**Oct-64**	**52.1**	0.0	0.00					1.160	44.91
46	35	**Nov-64**	**76.1**	0.0	0.00					1.653	46.02
47	36	**Dec-64**	**103.7**	0.0	0.00					2.073	50.02

Figure 3-2


Multiplicative seasonal adjustment
Actual
Adjusted
120
100
80
60
40
20
0
Jan-62
Mar-62
May-62
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Jul-64
Sep-64
Nov-64

3.2 Additive seasonal adjustment of monthly data (ADDITMON)

Let's try an alternative model on the champagne sales data. MULTIMON assumes that seasonal fluctuations are proportional to the level of the data. Thus the range of seasonal fluctuations increases with trend. In contrast, ADDITMON (Figure 3-3) assumes that seasonal fluctuations are constant in value, regardless of trend. Thus column E contains differences between actual and moving average instead of ratios. The average difference is computed in column H. They should sum to zero but do not because of rounding. To normalize in column I, the following is subtracted from each index: average difference / 12. Seasonal indices by month are repeated in column J. The adjusted data are then actual data minus the appropriate index. To summarize how additive indices are used:

Original data - Additive seasonal index = Deseasonalized data **(3-3)**

Deseasonalized data + Additive seasonal index = Original data **(3-4)**

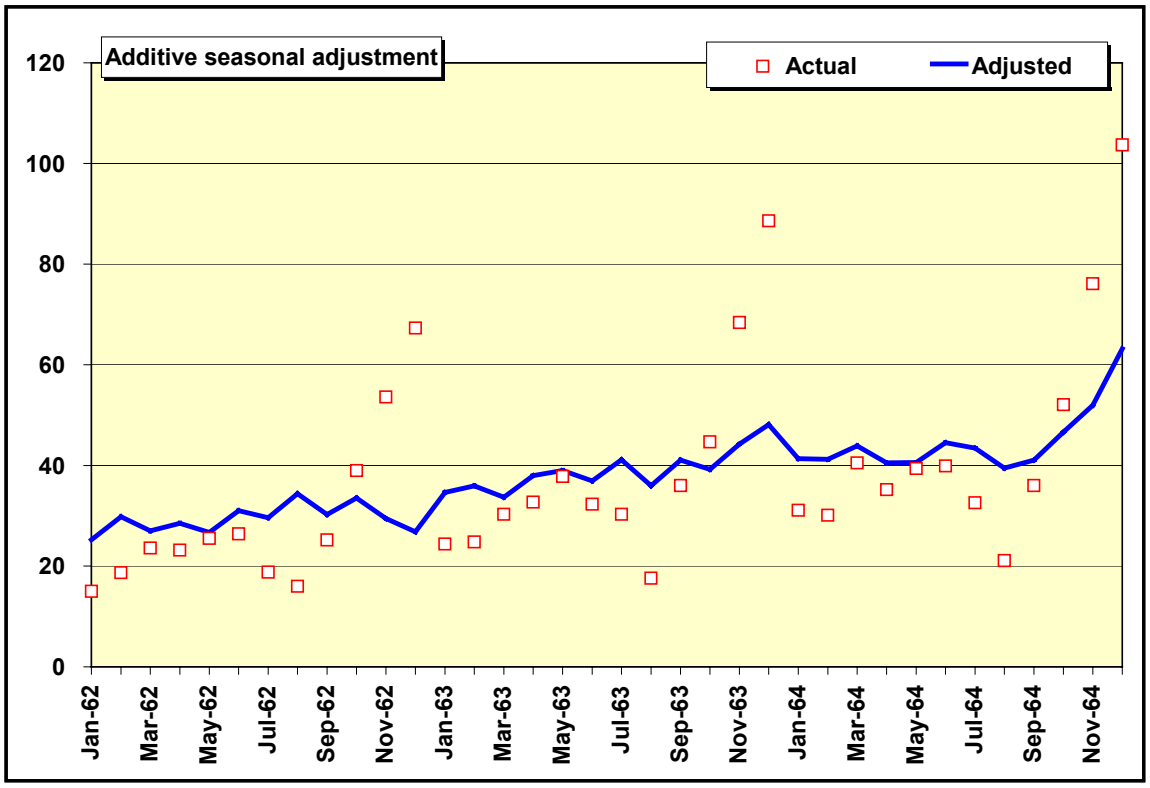
Additive adjustment does not work quite as well for the Hill County data as did multiplicative. The additive variance for adjusted data (cell J6) is somewhat larger than the multiplicative variance. The reason is that the seasonal pattern appears to be proportional to the level of the data, increasing as the data grow.

In business data, the type of seasonal adjustment that should be used is often unclear. We recommend that you test both procedures and use the one that produces the smallest variance. ADDITMON is usually better for noisy data, such as time series of inventory demands, because it is more resistant to outliers. When the data contain zeroes, ADDITMON is the only reasonable choice. In highly aggregated data, such as economic time series, multiplicative seasonality is common, making MULTIMON the best option.

Figure 3-3

	A	B	C	D	E	F	G	H	I	J	K
1	**ADDITMON**										
2	**Additive seasonal adjustment**										
3	**Name**	**Hill Country Champagne Sales**									
4											
5	**1st moving average at month**			7					**Actual**	**Adj.**	
6	**Last moving average at month**			31			**Variances**		418.2	63.9	
7	**Total number of data**			36			**Coeff. of variation**		54.2%	21.2%	
8											
9											
10		**Month**	**Actual**	**Moving**		**Sum of**	**# of**	**Avg.**	**Final**	**Monthly**	**Adj.**
11		**& year**	**data**	**avg.**	**Diff.**	**Diffs.**	**Diffs.**	**Diff.**	**index**	**index**	**data**
12	1	**Jan-62**	**15.0**	0.0	0.00	-19.83	2	-9.917	-10.253	-10.253	25.25
13	2	**Feb-62**	**18.7**	0.0	0.00	-21.58	2	-10.792	-11.128	-11.128	29.83
14	3	**Mar-62**	**23.6**	0.0	0.00	-6.11	2	-3.054	-3.391	-3.391	26.99
15	4	**Apr-62**	**23.2**	0.0	0.00	-9.91	2	-4.954	-5.291	-5.291	28.49
16	5	**May-62**	**25.5**	0.0	0.00	-1.70	2	-0.850	-1.186	-1.186	26.69
17	6	**Jun-62**	**26.4**	0.0	0.00	-8.58	2	-4.288	-4.624	-4.624	31.02
18	7	**Jul-62**	**18.8**	29.4	-10.56	-31.47	3	-10.489	-10.825	-10.825	29.63
19	8	**Aug-62**	**16.0**	30.1	-14.14	-36.09	2	-18.046	-18.382	-18.382	34.38
20	9	**Sep-62**	**25.2**	30.7	-5.45	-9.44	2	-4.721	-5.057	-5.057	30.26
21	10	**Oct-62**	**39.0**	31.2	7.79	11.65	2	5.825	5.489	5.489	33.51
22	11	**Nov-62**	**53.6**	32.0	21.60	48.95	2	24.475	24.139	24.139	29.46
23	12	**Dec-62**	**67.3**	33.0	34.28	81.69	2	40.846	40.509	40.509	26.79
24	13	**Jan-63**	**24.4**	33.5	-9.12		Sum	4.036	0.000	-10.253	34.65
25	14	**Feb-63**	**24.8**	34.5	-9.68					-11.128	35.93
26	15	**Mar-63**	**30.3**	34.6	-4.31					-3.391	33.69
27	16	**Apr-63**	**32.7**	35.5	-2.81					-5.291	37.99
28	17	**May-63**	**37.8**	36.0	1.82					-1.186	38.99
29	18	**Jun-63**	**32.3**	37.2	-4.92					-4.624	36.92
30	19	**Jul-63**	**30.3**	39.0	-8.69					-10.825	41.13
31	20	**Aug-63**	**17.6**	39.6	-21.95					-18.382	35.98
32	21	**Sep-63**	**36.0**	40.0	-3.99					-5.057	41.06
33	22	**Oct-63**	**44.7**	40.8	3.86					5.489	39.21
34	23	**Nov-63**	**68.4**	41.1	27.35					24.139	44.26
35	24	**Dec-63**	**88.6**	41.2	47.42					40.509	48.09
36	25	**Jan-64**	**31.1**	41.8	-10.72					-10.253	41.35
37	26	**Feb-64**	**30.1**	42.0	-11.91					-11.128	41.23
38	27	**Mar-64**	**40.5**	42.3	-1.80					-3.391	43.89
39	28	**Apr-64**	**35.2**	42.3	-7.10					-5.291	40.49
40	29	**May-64**	**39.4**	42.9	-3.52					-1.186	40.59
41	30	**Jun-64**	**39.9**	43.6	-3.66					-4.624	44.52
42	31	**Jul-64**	**32.6**	44.8	-12.22					-10.825	43.43
43	32	**Aug-64**	**21.1**	0.0	0.00					-18.382	39.48
44	33	**Sep-64**	**36.0**	0.0	0.00					-5.057	41.06
45	34	**Oct-64**	**52.1**	0.0	0.00					5.489	46.61
46	35	**Nov-64**	**76.1**	0.0	0.00					24.139	51.96
47	36	**Dec-64**	**103.7**	0.0	0.00					40.509	63.19

Figure 3-4


Additive seasonal adjustment
Actual
Adjusted
120
100
80
60
40
20
0
Jan-62
Mar-62
May-62
Jul-62
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