SEASONAL VARIATION

LO18-6

Compute and apply seasonal indexes to make seasonally adjusted forecasts.

We mentioned that *seasonal variation* is another of the components of a time series. Business series, such as automobile sales, shipments of soft-drink bottles, and residential construction, have periods of above-average and below-average activity each year. In the area of production, one of the reasons for analyzing seasonal fluctuations is to have a sufficient supply of raw materials on hand to meet the varying seasonal demand. The glass container division of a large glass company, for example, manufactures nonreturnable beer bottles, iodine bottles, aspirin bottles, bottles for rubber cement, and so on. The production scheduling department must know how many bottles to produce and when to produce each kind. A run of too many bottles of one kind may cause a serious storage problem. Production cannot be based entirely on orders on hand because many orders are telephoned in for immediate shipment. Since the demand for many of the bottles varies according to the season, a forecast a year or two in advance, by month, is essential to good scheduling.

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An analysis of seasonal fluctuations over a period of years can also help in evaluating current sales. The typical sales of department stores in the United States, excluding mail-order sales, are expressed as indexes in Table 18–5. Each index represents the average sales for a period of several years. The actual sales for some months were above average (which is represented by an index over 100.0), and the sales for other months were below average. The index of 126.8 for December indicates that, typically, sales for December are 26.8% above an average month; the index of 86.0 for July indicates that department store sales for July are typically 14% below an average month.

TABLE 18.5

TABLE 18–5 Typical Seasonal Indexes for U.S. Department Store Sales, Excluding Mail-Order Sales

January	87.0	July	86.0
February	83.2	August	99.7
March	100.5	September	101.4
April	106.5	October	105.8
May	101.6	November	111.9
June	89.6	December	126.8

TABLE 18–5
Typical Seasonal Indexes for U.S. Department Store Sales, Excluding Mail-Order Sales
January 87.0July 86.0
February 83.2August 99.7
March 100.5September101.4
April 106.5October 105.8
May 101.6November 111.9
June 89.6December 126.8

Suppose an enterprising store manager, in an effort to stimulate sales during December, introduced a number of unique promotions, including bands of carolers strolling through the store singing holiday songs, large mechanical exhibits, and clerks dressed in Santa Claus costumes. When the index of sales was computed for that December, it was 150.0. Compared with the typical December sales of 126.8, it was concluded that the promotional program was a huge success.

Determining a Seasonal Index

A typical set of monthly indexes consists of 12 indexes that are representative of the data for a 12-month period. Logically, there are four typical seasonal indexes for data reported quarterly. Each index is a percent, with the average for the year equal to 100.0; that is, each monthly index indicates the level of sales, production, or another variable in relation to the annual average of 100.0. A typical index of 96.0 for January indicates that sales (or whatever the variable is) are usually 4% below the average for the year. An index of 107.2 for October means that the variable is typically 7.2% above the annual average.

Several methods have been developed to measure the typical seasonal fluctuation in a time series. The method most commonly used to compute the typical seasonal pattern is called the **ratio-to-moving-average method.** It eliminates the trend, cyclical, and irregular components from the original data (Y). In the following discussion, T refers to trend, C to cyclical, S to seasonal, and I to irregular variation. The numbers that result are called the *typical seasonal index.*

We will discuss in detail the steps followed in arriving at typical seasonal indexes using the ratio-to-moving-average method. The data of interest might be monthly or quarterly. To illustrate, we have chosen the quarterly sales of Toys International. First, we will show the steps needed to arrive at a set of typical quarterly indexes. Then we use the MegaStat add-in for Excel to calculate the seasonal indexes.

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EXAMPLE

Table 18–6 shows the quarterly sales for Toys International for the years 2008 through 2013. The sales are reported in millions of dollars. Determine a quarterly seasonal index using the ratio-to-moving-average method.

TABLE 18.6

TABLE 18–6 Toys International Quarterly Sales ($ million), 2008 to 2013

Year	Winter	Spring	Summer	Fall
2008	6.7	4.6	10.0	12.7
2009	6.5	4.6	9.8	13.6
2010	6.9	5.0	10.4	14.1
2011	7.0	5.5	10.8	15.0
2012	7.1	5.7	11.1	14.5
2013	8.0	6.2	11.4	14.9

TABLE 18–6

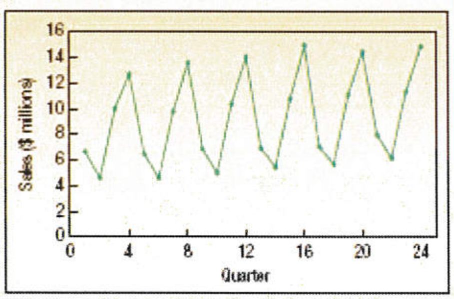
Toys International Quarterly Sales ($ million), 2008 to 2013

Year	Winter	Spring	Summer	Fall
2008	6.7	4.6	10.0	12.7
2009	6.5	4.6	9.8	13.6
2010	6.9	5.0	10.4	14.1
2011	7.0	5.5	10.8	15.0
2012	7.1	5.7	11.1	14.5
2013	8.0	6.2	11.4	14.9

SOLUTION

Chart 18–8 depicts the quarterly sales for Toys International over the six-year period. Notice the seasonal nature of the sales. For each year, the fourth-quarter sales are the largest and the second-quarter sales are the smallest. Also, there is a moderate increase in the sales from one year to the next. To observe this feature, look only at the six fourth-quarter sales values. Over the six-year period, the sales in the fourth quarter increased. You would expect a similar seasonal pattern for 2014.

Year	Quarter	Sales ($ Million)	Year	Quarter	Sales ($ Million)
2008	1	6.7	2011	1	7.0
	2	4.6		2	5.5
	3	10.0		3	10.8
	4	12.7		4	15.0
2009	1	6.5	2012	1	7.1
	2	4.6		2	5.7
	3	9.8		3	11.1
	4	13.6		4	14.5
2010	1	6.9	2013	1	8.0
	2	5.0		2	6.2
	3	10.4		3	11.4
	4	14.1		4	14.9



YearQuarterSales ($ Million)

Year	Quarter	Sales ($ Million)
2008	1	6.7
	2	4.6
	3	10.0
	4	12.7
2009	1	6.5
	2	4.6
	3	9.8
	4	13.6
2010	1	6.9

	2	5.0
	3	10.4
	4	14.1
2011	1	7.0
	2	5.5
	3	10.8
	4	15.0
2012	1	7.1
	2	5.7
	3	11.1
	4	14.5
2013	1	8.0
	2	6.2
	3	11.4
	4	14.9

CHART 18–8
Toys International Quarterly Sales in ($ Million), 2008 to 2013

There are six steps to determining the quarterly seasonal indexes.

- **Step 1:** For the following discussion, refer to Table 18–7. The first step is to determine the four-quarter moving total for 2008. Starting with the winter quarter of 2008, we add $6.7, $4.6, $10.0, and $12.7. The total is $34.0 (million). The four-quarter total is "moved along" by adding the spring, summer, and fall sales of 2008 to the winter sales of 2009. The total is $33.8 (million), found by 4.6 + 10.0 + 12.7 + 6.5. This procedure is continued for the quarterly sales for each of the six years. Column 2 of Table 18–7 shows all of the moving totals. Note that the moving total 34.0 is positioned between the spring and summer sales of 2008. The next moving total, 33.8, is positioned between sales for summer and fall 2008, and so on. Check the totals frequently to avoid arithmetic errors.

  TABLE 18.7

TABLE 18–7 Computations Needed for the Specific Seasonal Indexes

Year	Quarter	(1) Sales ($ millions)	(2) Four-Quarter Total	(3) Four-Quarter Moving Average	(4) Centered Moving Average	(5) Specific Seasonal
2008	Winter	6.7				
	Spring	4.6				
			34.0	8.500		
	Summer	10.0			8.475	1.180
			33.8	8.450		
	Fall	12.7			8.450	1.503
			33.8	8.450		
2009	Winter	6.5			8.425	0.772
			33.6	8.400		
	Spring	4.6			8.513	0.540
			34.5	8.625		
	Summer	9.8			8.675	1.130
			34.9	8.725		
	Fall	13.6			8.775	1.550
			35.3	8.825		
2010	Winter	6.9			8.900	0.775
			35.9	8.975		
	Spring	5.0			9.038	0.553
			36.4	9.100		
	Summer	10.4			9.113	1.141
			36.5	9.125		
	Fall	14.1			9.188	1.535
			37.0	9.250		
2011	Winter	7.0			9.300	0.753
			37.4	9.350		
	Spring	5.5			9.463	0.581
			38.3	9.575		
	Summer	10.8			9.588	1.126
			38.4	9.600		
	Fall	15.0			9.625	1.558
			38.6	9.650		
2012	Winter	7.1			9.688	0.733
			38.9	9.725		
	Spring	5.7			9.663	0.590
			38.4	9.600		
	Summer	11.1			9.713	1.143
			39.3	9.825		
	Fall	14.5			9.888	1.466
			39.8	9.950		
2013	Winter	8.0			9.888	0.801
			40.1	10.025		
	Spring	6.2			10.075	0.615
			40.5	10.125		
	Summer	11.4				
	Fall	14.9				

TABLE 18–7
Computations Needed for the Specific Seasonal Indexes

YearQuarter(1) Sales ($ (2) (3) Four-Quarter (4) Centered (5) Specific

	millions)	Four-Quarter Total	Moving Average	Moving Average	Seasonal
2008 Winter	6.7				
Spring	4.6				
		34.0	8.500		
Summer	10.0			8.475	1.180
		33.8	8.450		
Fall	12.7			8.450	1.503
		33.8	8.450		
2009 Winter	6.5			8.425	0.772
		33.6	8.400		
Spring	4.6			8.513	0.540
		34.5	8.625		
Summer	9.8			8.675	1.130
		34.9	8.725		
Fall	13.6			8.775	1.550
		35.3	8.825		
2010 Winter	6.9			8.900	0.775
		35.9	8.975		
Spring	5.0			9.038	0.553
		36.4	9.100		
Summer	10.4			9.113	1.141
		36.5	9.125		
Fall	14.1			9.188	1.535
		37.0	9.250		
2011 Winter	7.0			9.300	0.753
		37.4	9.350		
Spring	5.5			9.463	0.581
		38.3	9.575		
Summer	10.8			9.588	1.126
		38.4	9.600		
Fall	15.0			9.625	1.558
		38.6	9.650		
2012 Winter	7.1			9.688	0.733
		38.9	9.725		
Spring	5.7			9.663	0.590
		38.4	9.600		
Summer	11.1			9.713	1.143
		39.3	9.825		
Fall	14.5			9.888	1.466
		39.8	9.950		
2013 Winter	8.0			9.888	0.801
		40.1	10.025		
Spring	6.2			10.075	0.615
		40.5	10.125		
Summer	11.4				

Fall 14.9

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- **Step 2:** Each quarterly moving total in column 2 is divided by 4 to give the four-quarter moving average. (See column 3.) All the moving averages are still positioned between the quarters. For example, the first moving average (8.500) is positioned between spring and summer 2008.
- **Step 3:** The moving averages are then centered. The first centered moving average is found by (8.500 + 8.450)/2 = 8.475 and centered opposite summer 2008. The second moving average is found by (8.450 + 8.450)/2 = 8.450. The others are found similarly. Note in column 4 that a centered moving average is positioned on a particular quarter.
- **Step 4:** The **specific seasonal index** for each quarter is then computed by dividing the sales in column 1 by the centered moving average in column 4. The specific seasonal index reports the ratio of the original time series value to the moving average. To explain further, if the time series is represented by *TSCI* and the moving average by *TC,* then, algebraically, if we compute *TSCI*/*TC,* the result is the specified seasonal component *SI*. The specific seasonal index for the summer quarter of 2008 is 1.180, found by 10.0/8.475.
- **Step 5:** The specific seasonal indexes are organized in Table 18–8. This table will help us locate the specific seasonals for the corresponding quarters. The values 1.180, 1.130, 1.141, 1.126, and 1.143 all represent estimates of the typical seasonal index for the summer quarter. A reasonable method to find a typical seasonal index is to average these values in order to eliminate the irregular component. So we find the typical index for the summer quarter by (1.180 + 1.130 + 1.141 + 1.126 + 1.143)/5 = 1.144.

TABLE 18.8

TABLE 18–8 Calculations Needed for Typical Quarterly Indexes

Year	Winter	Spring	Summer	Fall	
2008			1.180	1.503	
2009	0.772	0.540	1.130	1.550	
2010	0.775	0.553	1.141	1.535	
2011	0.753	0.581	1.126	1.558	
2012	0.733	0.590	1.143	1.466	
2013	0.801	0.615			
Total	3.834	2.879	5.720	7.612	
Mean	0.767	0.576	1.144	1.522	4.009
Adjusted	0.765	0.575	1.141	1.519	4.000
Index	76.5	57.5	114.1	151.9	

TABLE 18–8

Calculations Needed for Typical Quarterly Indexes

Year	**Winter**	**Spring**	**Summer**	**Fall**
2008			1.180	1.503
2009	0.772	0.540	1.130	1.550
2010	0.775	0.553	1.141	1.535
2011	0.753	0.581	1.126	1.558
2012	0.733	0.590	1.143	1.466

2013	0.801	0.615		
Total	3.834	2.879	5.720	7.612
Mean	0.767	0.576	1.144	1.5224.009
Adjusted0.765		0.575	1.141	1.5194.000
Index	76.5	57.5	114.1	151.9

- **Step 6:** The four quarterly means (0.767, 0.576, 1.144, and 1.522) should theoretically total 4.00 because the average is set at 1.0. The total of the four quarterly means may not exactly equal 4.00 due to rounding. In this problem, the total of the means is 4.009. A *correction factor* is therefore applied to each of the four means to force them to total 4.00.

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CORRECTION FACTOR FOR ADJUSTING QUARTERLY MEANS

$$\text{Correction factor} = \frac{4.00}{\text{Total of four means}} \qquad \textbf{[18–3]}$$

In this example,

$$\text{Correction factor} = \frac{4.00}{4.009} = 0.997755$$

The adjusted winter quarterly index is, therefore, .767(.997755) = .765. Each of the means is adjusted downward so that the total of the four quarterly means is 4.00. Usually indexes are reported as percentages, so each value in the last row of Table 18–8 has been multiplied by 100. So the index for the winter quarter is 76.5 and for the fall it is 151.9. How are these values interpreted? Sales for the fall quarter are 51.9% above the typical quarter, and for winter they are 23.5% below the typical quarter (100.0 − 76.5). These findings should not surprise you. The period prior to Christmas (the fall quarter) is when toy sales are brisk. After Christmas (the winter quarter), sales of the toys decline drastically.

Statistical software can perform these calculations. For example, the output from the MegaStat add-in for Excel is shown below. Use of software will greatly reduce the computational time and the chance of an error in arithmetic, but you should understand the steps in the process, as outlined earlier. There can be slight differences in the answers, due to the number of digits carried in the calculations.

Centered Moving Average and Deseasonalization

t	Year	Quarter	Sales	Centered Moving Average	Ratio to CMA	Seasonal Indexes	Deseasonalized Sales
1	2008	1	6.70			0.765	8.759
2	2008	2	4.60			0.575	8.004
3	2008	3	10.00	8.475	1.180	1.141	8.761
4	2008	4	12.70	8.450	1.503	1.519	8.361
5	2009	1	6.50	8.425	0.772	0.765	8.498
6	2009	2	4.60	8.513	0.540	0.575	8.004
7	2009	3	9.80	8.675	1.130	1.141	8.586
8	2009	4	13.60	8.775	1.550	1.519	8.953
9	2010	1	6.90	8.900	0.775	0.765	9.021
10	2010	2	5.00	9.038	0.553	0.575	8.700
11	2010	3	10.40	9.113	1.141	1.141	9.112
12	2010	4	14.10	9.188	1.535	1.519	9.283
13	2011	1	7.00	9.300	0.753	0.765	9.151
14	2011	2	5.50	9.463	0.581	0.575	9.570
15	2011	3	10.80	9.588	1.126	1.141	9.462
16	2011	4	15.00	9.625	1.558	1.519	9.875
17	2012	1	7.10	9.688	0.733	0.765	9.282
18	2012	2	5.70	9.663	0.590	0.575	9.918
19	2012	3	11.10	9.713	1.143	1.141	9.725
20	2012	4	14.50	9.888	1.466	1.519	9.546
21	2013	1	8.00	9.988	0.801	0.765	10.459
22	2013	2	6.20	10.075	0.615	0.575	10.788
23	2013	3	11.40			1.141	9.988
24	2013	4	14.90			1.519	9.809

Centered Moving Average and Deseasonalization

t YearQuarterSales			Centered Moving Average	Ratio to CMA	Seasonal Indexes	Deseasonalized Sales
12008	1	6.70			0.765	8.759
22008	2	4.60			0.575	8.004
32008	3	10.008.475		1.180	1.141	8.761
42008	4	12.708.450		1.503	1.519	8.361
52009	1	6.50 8.425		0.772	0.765	8.498
62009	2	4.60 8.513		0.540	0.575	8.004
72009	3	9.80 8.675		1.130	1.141	8.586
82009	4	13.608.775		1.550	1.519	8.953
92010	1	6.90 8.900		0.775	0.765	9.021
102010	2	5.00 9.038		0.553	0.575	8.700
112010	3	10.409.113		1.141	1.141	9.112
122010	4	14.109.188		1.535	1.519	9.283
132011	1	7.00 9.300		0.753	0.765	9.151
142011	2	5.50 9.463		0.581	0.575	9.570
152011	3	10.809.588		1.126	1.141	9.462
162011	4	15.009.625		1.558	1.519	9.875
172012	1	7.10 9.688		0.733	0.765	9.282
182012	2	5.70 9.663		0.590	0.575	9.918
192012	3	11.109.713		1.143	1.141	9.725

202012	4	14.509.888	1.466	1.519	9.546
212013	1	8.00 9.988	0.801	0.765	10.459
222013	2	6.20 10.075	0.615	0.575	10.788
232013	3	11.40		1.141	9.988
242013	4	14.90		1.519	9.809

Calculation of Seasonal Indexes

	1	2	3	4	
2008			1.180	1.503	
2009	0.772	0.540	1.130	1.550	
2010	0.775	0.553	1.141	1.535	
2011	0.753	0.581	1.126	1.558	
2012	0.733	0.590	1.143	1.466	
2013	0.801	0.615			
Mean:	0.767	0.576	1.144	1.522	4.009
Adjusted:	0.765	0.575	1.141	1.519	4.000

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Now we briefly summarize the reasoning underlying the preceding calculations. The original data in column 1 of Table 18–7 contain trend (*T*), cyclical (*C*), seasonal (*S*), and irregular (*I*) components. The ultimate objective is to remove seasonal (*S*) from the original sales valuation.

Columns 2 and 3 in Table 18–7 are concerned with deriving the centered moving average given in column 4. Basically, we "average out" the seasonal and irregular fluctuations from the original data in column 1. Thus, in column 4 we have only trend and cyclical (*TC*).

Next, we divide the sales data in column 1 (*TCSI*) by the centered fourth-quarter moving average in column 4 (*TC*) to arrive at the specific seasonals in column 5 (*SI*). In terms of letters, *TCSI*/*TC* = *SI*. We multiply *SI* by 100.0 to express the typical seasonal in index form.

Finally, we take the mean of all the winter typical indexes, all the spring indexes, and so on. This averaging eliminates most of the irregular fluctuations from the specific seasonals, and the resulting four indexes indicate the typical seasonal sales pattern.

SELF-REVIEW 18–4

Teton Village, Wyoming, near Grand Teton Park and Yellowstone Park, contains shops, restaurants, and motels. The village has two peak seasons—winter, for skiing on the 10,000-foot slopes, and summer, for tourists visiting the parks. The number of visitors (in thousands) by quarter for 5 years, 2009 through 2013, follows.

	Quarter			
Year	Winter	Spring	Summer	Fall
2009	117.0	80.7	129.6	76.1
2010	118.6	82.5	121.4	77.0
2011	114.0	84.3	119.9	75.0
2012	120.7	79.6	130.7	69.6
2013	125.2	80.2	127.6	72.0

Quarter
YearWinterSpringSummerFall
2009 117.0 80.7 129.6 76.1
2010 118.6 82.5 121.4 77.0
2011 114.0 84.3 119.9 75.0
2012 120.7 79.6 130.7 69.6
2013 125.2 80.2 127.6 72.0

(a) Develop the typical seasonal pattern for Teton Village using the ratio-to-moving-average method.

(b) Explain the typical index for the winter season.

EXERCISES
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9. Victor Anderson, the owner of Anderson Belts Inc., is studying absenteeism among his employees. His workforce is small, consisting of only five employees. For the last 3 years, 2011 through 2013, he recorded the following number of employee absences, in days, for each quarter.

For **DATA FILE**, please visit **www.mhhe.com/lind16e**

	Quarter			
Year	I	II	III	IV
2011	4	10	7	3
2012	5	12	9	4
2013	6	16	12	4

Quarter
YearI II IIIIV
2011410 7 3
2012512 9 4
201361612 4

Determine a typical seasonal index for each of the four quarters.

10. Appliance Center sells a variety of electronic equipment and home appliances. For the last 4 years,

2010 through 2013, the following quarterly sales (in $ millions) were reported.

For **DATA FILE**, please visit **www.mhhe.com/lind16e**

	Quarter			
Year	I	II	III	IV
2010	5.3	4.1	6.8	6.7
2011	4.8	3.8	5.6	6.8
2012	4.3	3.8	5.7	6.0
2013	5.6	4.6	6.4	5.9

Quarter
Year I II III IV
20105.34.16.86.7
20114.83.85.66.8
20124.33.85.76.0
20135.64.66.45.9

Determine a typical seasonal index for each of the four quarters.