10 or more years) and magnitude, and they are very difficult to predict. Seasonal variations are very consistent in length and magnitude, are much shorter as the seasons repeat in a year or less, and are much easier to predict. The forecasting models presented in this chapter will be for short-range or medium-range forecasts and the cyclical component will not be included in these models.

The **random** (R) **component** consists of irregular, unpredictable variations in a time series. Any variation in a times series that cannot be attributed to trend, seasonal, or cyclical variations would fall into this category. If data for a time series tends to be level with no discernible trend or seasonal pattern, random variations would be the cause for any changes from one time period to the next. Series 1 in Figure 5.2 is an example of a time series with only a random component.

There are two general forms of time-series models in statistics. The first is a multiplicative model, which assumes that demand is the product of the four components. It is stated as follows:

$$\text{Demand} = \text{T} \times \text{S} \times \text{C} \times \text{R}$$

An additive model adds the components together to provide an estimate. Multiple regression is often used to develop additive models. This additive relationship is stated as follows:

$$\text{Demand} = \text{T} + \text{S} + \text{C} + \text{R}$$

There are other models that may be a combination of these. For example, one of the components (such as trend) might be additive while another (such as seasonality) could be multiplicative. Understanding the components of a time series will help in selecting an appropriate forecasting technique to use. The methods presented in this chapter will be grouped according to the components considered when the forecast is developed.

5.4 Measures of Forecast Accuracy

We discuss several different forecasting models in this chapter. To see how well one model works, or to compare that model with other models, the forecast values are compared with the actual or observed values. The **forecast error (or deviation)** is defined as follows:

$$\text{Forecast error} = \text{Actual value} - \text{Forecast value}$$

One measure of accuracy is the **mean absolute deviation (MAD)**. This is computed by taking the sum of the absolute values of the individual forecast errors and dividing by the numbers of errors (n):

$$\text{MAD} = \frac{\sum|\text{forecast error}|}{n} \tag{5-1}$$

TABLE 5.1
Computing the Mean Absolute Deviation (MAD)

MONTH	ACTUAL SALES OF WIRELESS SPEAKERS	FORECAST SALES	ABSOLUTE VALUE OF ERRORS (DEVIATION), |ACTUAL–FORECAST|
1	110	—	—
2	100	110	$\|100 - 110\| = 10$
3	120	100	$\|120 - 100\| = 20$
4	140	120	$\|140 - 120\| = 20$
5	170	140	$\|170 - 140\| = 30$
6	150	170	$\|150 - 170\| = 20$
7	160	150	$\|160 - 150\| = 10$
8	190	160	$\|190 - 160\| = 30$
9	200	190	$\|200 - 190\| = 10$
10	190	200	$\|190 - 200\| = 10$
11	—	190	—
			Sum of $\|\text{errors}\| = 160$
			MAD = 160/9 = 17.8