

**SOLUTION**

$$E = 2 + 1 - 2 + 13 - 3 - 5 = 6$$

The cumulative error ( $E$ ) for this dataset is 6, which indicates that the forecasts are consistently underestimating the actual data. However, a closer look at the forecast errors reveals that there are ups and downs and the positive value of  $E$  is primarily a result of the forecast for Period 4 which underestimates the actual value by 13 units. Thus, examining just  $E$  is somewhat of a disadvantage given that three of the forecasts are overestimations and three are underestimations. This drawback is overcome by the tracking signal error metric.

**Tracking Signal (TS)**

As can be seen in Example 15.4.4, bias should never be confirmed using a single measure. Bias should be observed over time, which is the primary purpose of the **tracking signal (TS)**. It is computed for each time period using the following formula.

$$TS = \frac{E}{MAD}$$

There are typically two ground rules to detect bias using the tracking signal, which are based on the control chart principles (see Chapter 18). The first rule is that any time the  $TS$  is above +4 or below -4, it is considered to be “out of control” and the forecast is biased. The second rule is to ensure that the  $TS$  has no trend, increasing upwards or decreasing downwards, for any considerable amount of time. A trend in the  $TS$  indicates that the forecasts are inching towards being biased and some corrective measures should be taken, such as using a different forecasting method.

Using the data in Example 15.4.1, compute the tracking signal ( $TS$ ).

Time Period, $t$	Actual data, $D_t$	Forecast, $F_t$	Error, $FE_t$	$E$	MAD	$TS = \frac{E}{MAD}$
1	134	132	2	2	2.00	1.00
2	142	141	1	3	1.500	2.00
3	143	145	-2	1	1.667	0.60
4	156	143	13	14	4.500	3.11
5	151	154	-3	11	4.200	2.62
6	145	150	-5	6	4.333	1.38

**SOLUTION**

As you can see from the above table, the forecast is biased as indicated by  $E$ . But the  $TS$  is within +4 and -4 and there is no discernible trend; it goes up and down randomly. There are several error metrics in forecasting analysis. They all let you make the same decisions—whether the forecast is good or not. Depending upon our need, we could choose the appropriate error metric on which to focus. For example, MAPD is suggested for accuracy,  $TS$  is suggested for bias, and MSE is suggested for outliers.

**Example 15.4.5****Calculating the Tracking Signal for Forecasts****15.4 Exercises****Basic Concepts**

1. What is forecast error?
2. If the forecast error is positive, what does it mean? What if it is negative?
3. Mean absolute deviation relies on which variable in order to assess if the forecast is good or not?

4. Describe one key difference between mean absolute deviation and mean absolute percentage error.
5. What is one draw back from the mean absolute percentage error that makes this error metric not so popular?
6. What is the only way that mean absolute percentage deviation is indeterminate?
7. When is the mean squared error especially useful?
8. Having a lower (or higher) error forecast, but consistently below (or above) the time series actual value is an indicator of what?
9. What does a positive/negative cumulative error indicate?
10. What is the drawback in cumulative error that is overcome by the tracking signal?

**Exercises**

**Data**

The data set can be found by visiting [stat.hawkeslearning.com](http://stat.hawkeslearning.com) and navigating to **Discovering Business Statistics, Second Edition > Data Sets > Border Crossings**.

**Data**

The data set can be found by visiting [stat.hawkeslearning.com](http://stat.hawkeslearning.com) and navigating to **Discovering Business Statistics, Second Edition > Data Sets > Monthly Average Retail Gas Prices**.

11. Use the Border Crossings data set. For the 3-month SMA forecast of Laredo truck crossings, compute the MAPD and plot the *TS*. Is the forecast good?
12. Use the Border Crossings data set. For the simple exponential smoothing forecast of Detroit truck crossings, compute the MAPD and plot the *TS*. Is the forecast good? (Use  $\alpha = 0.2$ .)
13. Use the Border Crossings data set. For the adjusted exponential smoothing forecast of Laredo truck crossings, compute the MAPD and plot the *TS*. Is the forecast good? (Use  $\alpha = 0.2$ ;  $\beta = 0.4$ .)
14. Use the Monthly Average Retail Gas Prices data set, which includes the average gas prices in the U.S. from April 1993 to July 2021. Perform a simple exponential smoothing forecast of retail gasoline price and compute the MSE. (Use  $\alpha = 0.3$ .)
15. Use the Monthly Average Retail Gas Prices data set, which includes the average gas prices in the U.S. from April 1993 to July 2021. Perform an adjusted exponential smoothing forecast of retail gasoline price and compute the MAPD. (Use  $\alpha = 0.3$ ;  $\beta = 0.4$ .)
16. Use the Monthly Average Retail Gas Prices data set, which includes the average gas prices in the U.S. from April 1993 to July 2021. Calculate the best  $\alpha, \beta$  combination that minimizes the MAPD of the forecast for retail gasoline price.
17. Which error metric(s) should we concentrate on for each forecasting objective?

Objective	Error Metrics
Minimize Outliers	
Minimize Overall Forecast Errors	
Minimize Bias	
Minimize Overall Forecast Errors of intermittent items	