Forecasting

CHAPTER 4

CHAPTER OUTLINE

GLOBAL COMPANY PROFILE: *Walt Disney Parks & Resorts*

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Alaska Airlines

GLOBAL COMPANY PROFILE
Walt Disney Parks & Resorts

Forecasting Provides a Competitive Advantage for Disney

When it comes to the world's most respected global brands, Walt Disney Parks & Resorts is a visible leader. Although the monarch of this magic kingdom is no man but a mouse—Mickey Mouse—it's CEO Robert Iger who daily manages the entertainment giant. Disney's global portfolio includes Shanghai Disney (2016), Hong Kong Disneyland (2005), Disneyland Paris (1992), and Tokyo Disneyland (1983). But it is Walt Disney World Resort (in Florida) and Disneyland Resort (in California) that drive profits in this $50 billion corporation, which is ranked in the top 100 in both the *Fortune* 500 and *Financial Times* Global 500.

Revenues at Disney are all about people—how many visit the parks and how they spend money while there. When Iger receives a daily report from his four theme parks and two water parks near Orlando, the report contains only two numbers: the *forecast* of yesterday's attendance at the parks (Magic Kingdom, Epcot, Disney's Animal Kingdom, Disney-Hollywood Studios, Typhoon Lagoon, and Blizzard Beach) and the *actual* attendance. An error close to zero is expected. Iger takes his forecasts very seriously.

The forecasting team at Walt Disney World Resort doesn't just do a daily prediction, however, and Iger is not its only customer. The team also provides daily, weekly, monthly, annual, and 5-year forecasts to the labor management, maintenance, operations, finance, and park scheduling departments. Forecasters use judgmental models, econometric models, moving-average models, and regression analysis.

Travelshots/Peter Phipp/Travelshots.com/Alamy

Donald Duck, Goofy, and Mickey Mouse provide the public image of Disney to the world. Forecasts drive the work schedules of 72,000 cast members working at Walt Disney World Resort near Orlando.

Nicolas Chan/Alamy

The giant sphere is the symbol of Epcot, one of Disney's four Orlando parks, for which forecasts of meals, lodging, entertainment, and transportation must be made. This Disney monorail moves guests among parks and the 28 hotels on the massive 47-square-mile property (about the size of San Francisco and twice the size of Manhattan).

LEARNING OBJECTIVES

LO 4.1 ***Understand*** the three time horizons and which models apply for each 108

LO 4.2 ***Explain*** when to use each of the four qualitative models 111

LO 4.3 ***Apply*** the naive, moving-average, exponential smoothing, and trend methods 113

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What Is Forecasting?

Every day, managers like those at Disney make decisions without knowing what will happen in the future. They order inventory without knowing what sales will be, purchase new equipment despite uncertainty about demand for products, and make investments without knowing what profits will be. Managers are always trying to make better estimates of what will happen in the future in the face of uncertainty. Making good estimates is the main purpose of forecasting.

STUDENT TIP An increasingly complex world economy makes forecasting challenging.

In this chapter, we examine different types of forecasts and present a variety of forecasting models. Our purpose is to show that there are many ways for managers to forecast. We also provide an overview of business sales forecasting and describe how to prepare, monitor, and judge the accuracy of a forecast. Good forecasts are an *essential* part of efficient service and manufacturing operations.

Forecasting
The art and science of predicting future events.

Forecasting is the art and science of predicting future events. Forecasting may involve taking historical data (such as past sales) and projecting them into the future with a mathematical model. It may be a subjective or an intuitive prediction (e.g., "this is a great new product and will sell 20% more than the old one"). It may be based on demand-driven data, such as customer plans to purchase, and projecting them into the future. Or the forecast may involve a combination of these, that is, a mathematical model adjusted by a manager's good judgment.

As we introduce different forecasting techniques in this chapter, you will see that there is seldom one superior method. Forecasts may be influenced by a product's position in its life cycle—whether sales are in an introduction, growth, maturity, or decline stage. Other products can be influenced by the demand for a related product—for example, navigation systems may track with new car sales. Because there are limits to what can be expected from forecasts, we develop error measures. Preparing and monitoring forecasts can also be costly and time consuming.

Few businesses, however, can afford to avoid the process of forecasting by just waiting to see what happens and then taking their chances. Effective planning in both the short run and long run depends on a forecast of demand for the company's products.

Forecasting Time Horizons

LO 4.1 *Understand* the three time horizons and which models apply for each

A forecast is usually classified by the *future time horizon* that it covers. Time horizons fall into three categories:

1. *Short-range forecast:* This forecast has a time span of up to 1 year but is generally less than 3 months. It is used for planning purchasing, job scheduling, workforce levels, job assignments, and production levels.
2. *Medium-range forecast:* A medium-range, or intermediate, forecast generally spans from 3 months to 3 years. It is useful in sales planning, production planning and budgeting, cash budgeting, and analysis of various operating plans.
3. *Long-range forecast:* Generally 3 years or more in time span, long-range forecasts are used in planning for new products, capital expenditures, facility location or expansion, and research and development.

Medium- and long-range forecasts are distinguished from short-range forecasts by three features:

1. First, intermediate and long-range forecasts *deal with more comprehensive issues* supporting management decisions regarding planning and products, plants, and processes. Implementing some facility decisions, such as GM's decision to open a new Brazilian manufacturing plant, can take 5 to 8 years from inception to completion.
2. Second, short-term forecasting usually *employs different methodologies* than longer-term forecasting. Mathematical techniques, such as moving averages, exponential smoothing, and trend extrapolation (all of which we shall examine shortly), are common to short-run projections. Broader, *less* quantitative methods are useful in predicting such issues as whether a new product, like the optical disk recorder, should be introduced into a company's product line.
3. Finally, as you would expect, short-range forecasts *tend to be more accurate* than longer-range forecasts. Factors that influence demand change every day. Thus, as the time horizon lengthens, it is likely that forecast accuracy will diminish. It almost goes without saying, then, that sales forecasts must be updated regularly to maintain their value and integrity. After each sales period, forecasts should be reviewed and revised.

Types of Forecasts

Organizations use three major types of forecasts in planning future operations:

1. **Economic forecasts** address the business cycle by predicting inflation rates, money supplies, housing starts, and other planning indicators.
2. **Technological forecasts** are concerned with rates of technological progress, which can result in the birth of exciting new products, requiring new plants and equipment.
3. **Demand forecasts** are projections of demand for a company's products or services. Forecasts drive decisions, so managers need immediate and accurate information about real demand. They need *demand-driven forecasts*, where the focus is on rapidly identifying and tracking customer desires. These forecasts may use recent point-of-sale (POS) data, retailer-generated reports of customer preferences, and any other information that will help to forecast with the most current data possible. Demand-driven forecasts drive a company's production, capacity, and scheduling systems and serve as inputs to financial, marketing, and personnel planning. In addition, the payoff in reduced inventory and obsolescence can be huge.

Economic forecasts
Planning indicators that are valuable in helping organizations prepare medium- to long-range forecasts.

Technological forecasts
Long-term forecasts concerned with the rates of technological progress.

Demand forecasts
Projections of a company's sales for each time period in the planning horizon.

Economic and technological forecasting are specialized techniques that may fall outside the role of the operations manager. The emphasis in this chapter will therefore be on demand forecasting.

The Strategic Importance of Forecasting

Good forecasts are of critical importance in all aspects of a business: *The forecast is the only estimate of demand until actual demand becomes known.* Forecasts of demand therefore drive decisions in many areas. Let's look at the impact of product demand forecast on three activities: (1) supply-chain management, (2) human resources, and (3) capacity.

Supply-Chain Management

Good supplier relations and the ensuing advantages in product innovation, cost, and speed to market depend on accurate forecasts. Here are just three examples:

- Apple has built an effective global system where it controls nearly every piece of the supply chain, from product design to retail store. With rapid communication and accurate data shared up and down the supply chain, innovation is enhanced, inventory costs are reduced, and speed to market is improved. Once a product goes on sale, Apple tracks demand by the hour for each store and adjusts production forecasts daily. At Apple, forecasts for its supply chain are a strategic weapon.

- Toyota develops sophisticated car forecasts with input from a variety of sources, including dealers. But forecasting the demand for accessories such as navigation systems, custom wheels, spoilers, and so on is particularly difficult. And there are over 1,000 items that vary by model and color. As a result, Toyota not only reviews reams of data with regard to vehicles that have been built and wholesaled but also looks in detail at vehicle forecasts before it makes judgments about the future accessory demand. When this is done correctly, the result is an efficient supply chain and satisfied customers.
- Walmart collaborates with suppliers such as Sara Lee and Procter & Gamble to make sure the right item is available at the right time in the right place and at the right price. For instance, in hurricane season, Walmart's ability to analyze 700 million store–item combinations means it can forecast that not only flashlights but also Pop-Tarts and beer sell at seven times the normal demand rate. These forecasting systems are known as *collaborative planning, forecasting, and replenishment* (CPFR). They combine the intelligence of multiple supply-chain partners. The goal of CPFR is to create significantly more accurate information that can power the supply chain to greater sales and profits.

Human Resources

Hiring, training, and laying off workers all depend on anticipated demand. If the human resources department must hire additional workers without warning, the amount of training declines, and the quality of the workforce suffers. A large Louisiana chemical firm almost lost its biggest customer when a quick expansion to around-the-clock shifts led to a total breakdown in quality control on the second and third shifts.

Capacity

When capacity is inadequate, the resulting shortages can lead to loss of customers and market share. This is exactly what happened to Nabisco when it underestimated the huge demand for its new Snackwell Devil's Food Cookies. Even with production lines working overtime, Nabisco could not keep up with demand, and it lost customers. Nintendo faced this problem when its Wii was introduced and exceeded all forecasts for demand. Amazon made the same error with its Kindle. On the other hand, when excess capacity exists, costs can skyrocket.

Seven Steps in the Forecasting System

Forecasting follows seven basic steps. We use Disney World, the focus of this chapter's *Global Company Profile*, as an example of each step:

1. *Determine the use of the forecast:* Disney uses park attendance forecasts to drive decisions about staffing, opening times, ride availability, and food supplies.
2. *Select the items to be forecasted:* For Disney World, there are six main parks. A forecast of daily attendance at each is the main number that determines labor, maintenance, and scheduling.
3. *Determine the time horizon of the forecast:* Is it short, medium, or long term? Disney develops daily, weekly, monthly, annual, and 5-year forecasts.
4. *Select the forecasting model(s):* Disney uses a variety of statistical models that we shall discuss, including moving averages, econometrics, and regression analysis. It also employs judgmental, or nonquantitative, models.
5. *Gather the data needed to make the forecast:* Disney's forecasting team employs 35 analysts and 70 field personnel to survey 1 million people/businesses every year. Disney also uses a firm called Global Insights for travel industry forecasts and gathers data on exchange rates, arrivals into the U.S., airline specials, Wall Street trends, and school vacation schedules.

6. *Make the forecast.*
7. *Validate and implement the results:* At Disney, forecasts are reviewed daily at the highest levels to make sure that the model, assumptions, and data are valid. Error measures are applied; then the forecasts are used to schedule personnel down to 15-minute intervals.

These seven steps present a systematic way of initiating, designing, and implementing a forecasting system. When the system is to be used to generate forecasts regularly over time, data must be routinely collected. Then actual computations are usually made by computer.

Regardless of the system that firms like Disney use, each company faces several realities:

- Outside factors that we cannot predict or control often impact the forecast.
- Most forecasting techniques assume that there is some underlying stability in the system. Consequently, some firms automate their predictions using computerized forecasting software, then closely monitor only the product items whose demand is erratic.
- Both product family and aggregated forecasts are more accurate than individual product forecasts. Disney, for example, aggregates daily attendance forecasts by park. This approach helps balance the over- and underpredictions for each of the six attractions.

Forecasting Approaches

There are two general approaches to forecasting, just as there are two ways to tackle all decision modeling. One is a quantitative analysis; the other is a qualitative approach. **Quantitative forecasts** use a variety of mathematical models that rely on historical data and/or associative variables to forecast demand. Subjective or **qualitative forecasts** incorporate such factors as the decision maker's intuition, emotions, personal experiences, and value system in reaching a forecast. Some firms use one approach and some use the other. In practice, a combination of the two is usually most effective.

Quantitative forecasts
Forecasts that employ mathematical modeling to forecast demand.

Qualitative forecasts
Forecasts that incorporate such factors as the decision maker's intuition, emotions, personal experiences, and value system.

Overview of Qualitative Methods

In this section, we consider four different *qualitative* forecasting techniques:

1. **Jury of executive opinion**: Under this method, the opinions of a group of high-level experts or managers, often in combination with statistical models, are pooled to arrive at a group estimate of demand. Bristol-Myers Squibb Company, for example, uses 220 well-known research scientists as its jury of executive opinion to get a grasp on future trends in the world of medical research.
2. **Delphi method**: There are three different types of participants in the Delphi method: decision makers, staff personnel, and respondents. Decision makers usually consist of a group of 5 to 10 experts who will be making the actual forecast. Staff personnel assist decision makers by preparing, distributing, collecting, and summarizing a series of questionnaires and survey results. The respondents are a group of people, often located in different places, whose judgments are valued. This group provides inputs to the decision makers before the forecast is made.

   The state of Alaska, for example, has used the Delphi method to develop its long-range economic forecast. A large part of the state's budget is derived from the million-plus barrels of oil pumped daily through a pipeline at Prudhoe Bay. The large Delphi panel of experts had to represent all groups and opinions in the state and all geographic areas.
3. **Sales force composite**: In this approach, each salesperson estimates what sales will be in his or her region. These forecasts are then reviewed to ensure that they are realistic. Then they are combined at the district and national levels to reach an overall forecast. A variation of this approach occurs at Lexus, where every quarter Lexus dealers have a "make meeting." At this meeting, they talk about what is selling, in what colors, and with what options, so the factory knows what to build.
4. **Market survey**: This method solicits input from customers or potential customers regarding future purchasing plans. It can help not only in preparing a forecast but also in improving

Jury of executive opinion
A forecasting technique that uses the opinion of a small group of high-level managers to form a group estimate of demand.

Delphi method
A forecasting technique using a group process that allows experts to make forecasts.

LO 4.2 *Explain* when to use each of the four qualitative models

Sales force composite
A forecasting technique based on salespersons' estimates of expected sales.

Market survey
A forecasting method that solicits input from customers or potential customers regarding future purchasing plans.

product design and planning for new products. The consumer market survey and sales force composite methods can, however, suffer from overly optimistic forecasts that arise from customer input.

Overview of Quantitative Methods[1]

Five quantitative forecasting methods, all of which use historical data, are described in this chapter. They fall into two categories:

1. Naive approach
2. Moving averages
3. Exponential smoothing
4. Trend projection

} **Time-series models** (1–4)

5. Linear regression } **Associative model**

Time series
A forecasting technique that uses a series of past data points to make a forecast.

Time-Series Models Time-series models predict on the assumption that the future is a function of the past. In other words, they look at what has happened over a period of time and use a series of past data to make a forecast. If we are predicting sales of lawn mowers, we use the past sales for lawn mowers to make the forecasts.

Associative Models Associative models, such as linear regression, incorporate the variables or factors that might influence the quantity being forecast. For example, an associative model for lawn mower sales might use factors such as new housing starts, advertising budget, and competitors' prices.

STUDENT TIP
Here is the meat of this chapter. We now show you a wide variety of models that use time-series data.

Time-Series Forecasting

A time series is based on a sequence of evenly spaced (weekly, monthly, quarterly, and so on) data points. Examples include weekly sales of Nike Air Jordans, quarterly earnings reports of Microsoft stock, daily shipments of Coors beer, and annual consumer price indices. Forecasting time-series data implies that future values are predicted *only* from past values and that other variables, no matter how potentially valuable, may be ignored.

Decomposition of a Time Series

Analyzing time series means breaking down past data into components and then projecting them forward. A time series has four components:

STUDENT TIP
The peak "seasons" for sales of Frito-Lay chips are the Super Bowl, Memorial Day, Labor Day, and the Fourth of July.

1. *Trend* is the gradual upward or downward movement of the data over time. Changes in income, population, age distribution, or cultural views may account for movement in trend.
2. *Seasonality* is a data pattern that repeats itself after a period of days, weeks, months, or quarters. There are six common seasonality patterns:

PERIOD LENGTH	"SEASON" LENGTH	NUMBER OF "SEASONS" IN PATTERN
Week	Day	7
Month	Week	$4\text{–}4\frac{1}{2}$
Month	Day	28–31
Year	Quarter	4
Year	Month	12
Year	Week	52

Restaurants and barber shops, for example, experience weekly seasons, with Saturday being the peak of business. See the *OM in Action* box "Forecasting at Olive Garden." Beer distributors forecast yearly patterns, with monthly seasons. Three "seasons"—May, July, and September—each contain a big beer-drinking holiday.

APPROACH ▶ To compute a seasonalized or adjusted sales forecast, we just multiply each seasonal index by the appropriate trend forecast:

$$\hat{y}_{\text{seasonal}} = \text{Index} \times \hat{y}_{\text{trend forecast}}$$

SOLUTION ▶

Quarter I: $\hat{y}_{\text{I}} = (1.30)(\$100{,}000) = \$130{,}000$
Quarter II: $\hat{y}_{\text{II}} = (.90)(\$120{,}000) = \$108{,}000$
Quarter III: $\hat{y}_{\text{III}} = (.70)(\$140{,}000) = \$98{,}000$
Quarter IV: $\hat{y}_{\text{IV}} = (1.10)(\$160{,}000) = \$176{,}000$

INSIGHT ▶ The straight-line trend forecast is now adjusted to reflect the seasonal changes.

LEARNING EXERCISE ▶ If the sales forecast for Quarter IV was \$180,000 (rather than \$160,000), what would be the seasonally adjusted forecast? [Answer: \$198,000.]

RELATED PROBLEMS ▶ 4.25, 4.28 (4.41b is available in MyOMLab)

Cyclical Variations in Data

Cycles are like seasonal variations in data but occur every several *years*, not weeks, months, or quarters. Forecasting cyclical variations in a time series is difficult. This is because cycles include a wide variety of factors that cause the economy to go from recession to expansion to recession over a period of years. These factors include national or industrywide overexpansion in times of euphoria and contraction in times of concern. Forecasting demand for individual products can also be driven by product life cycles—the stages products go through from introduction through decline. Life cycles exist for virtually all products; striking examples include floppy disks, video recorders, and the original Game Boy. We leave cyclical analysis to forecasting texts.

Developing associative techniques of variables that affect one another is our next topic.

Cycles
Patterns in the data that occur every several years.

Associative Forecasting Methods: Regression and Correlation Analysis

STUDENT TIP
We now deal with the same mathematical model that we saw earlier, the least-squares method. But we use any potential "cause-and-effect" variable as *x*.

Unlike time-series forecasting, *associative forecasting* models usually consider *several* variables that are related to the quantity being predicted. Once these related variables have been found, a statistical model is built and used to forecast the item of interest. This approach is more powerful than the time-series methods that use only the historical values for the forecast variable.

Many factors can be considered in an associative analysis. For example, the sales of Dell PCs may be related to Dell's advertising budget, the company's prices, competitors' prices and promotional strategies, and even the nation's economy and unemployment rates. In this case, PC sales would be called the *dependent variable*, and the other variables would be called *independent variables*. The manager's job is to develop *the best statistical relationship between PC sales and the independent variables*. The most common quantitative associative forecasting model is **linear-regression analysis**.

Linear-regression analysis
A straight-line mathematical model to describe the functional relationships between independent and dependent variables.

Using Regression Analysis for Forecasting

We can use the same mathematical model that we employed in the least-squares method of trend projection to perform a linear-regression analysis. The dependent variables that we want to forecast will still be $\hat{y}$. But now the independent variable, x, need no longer be time. We use the equation:

$$\hat{y} = a + bx$$

where
$\hat{y}$ = value of the dependent variable (in our example, sales)
a = y-axis intercept
b = slope of the regression line
x = independent variable

LO 4.6 *Conduct* a regression and correlation analysis

Example 12 shows how to use linear regression.

Monitoring and Controlling Forecasts

Once a forecast has been completed, it should not be forgotten. No manager wants to be reminded that his or her forecast is horribly inaccurate, but a firm needs to determine why actual demand (or whatever variable is being examined) differed significantly from that projected. If the forecaster is accurate, that individual usually makes sure that everyone is aware of his or her talents. Very seldom does one read articles in *Fortune*, *Forbes*, or *The Wall Street Journal*, however, about money managers who are consistently off by 25% in their stock market forecasts.

One way to monitor forecasts to ensure that they are performing well is to use a tracking signal. A **tracking signal** is a measurement of how well a forecast is predicting actual values. As forecasts are updated every week, month, or quarter, the newly available demand data are compared to the forecast values.

Tracking signal
A measurement of how well a forecast is predicting actual values.

The tracking signal is computed as the cumulative error divided by the *mean absolute deviation (MAD)*:

$$\text{Tracking signal} = \frac{\text{Cumulative error}}{\text{MAD}} \tag{4-18}$$

$$= \frac{\sum(\text{Actual demand in period } i - \text{Forecast demand in period } i)}{\text{MAD}}$$

where $\text{MAD} = \dfrac{\sum|\text{Actual} - \text{Forecast}|}{n}$

as seen earlier, in Equation (4-5).

STUDENT TIP
Using a tracking signal is a good way to make sure the forecasting system is continuing to do a good job.

Positive tracking signals indicate that demand is *greater* than forecast. *Negative* signals mean that demand is *less* than forecast. A good tracking signal—that is, one with a low cumulative error—has about as much positive error as it has negative error. In other words, small deviations are okay, but positive and negative errors should balance one another so that the tracking signal centers closely around zero. A consistent tendency for forecasts to be greater or less than the actual values (that is, for a high absolute cumulative error) is called a **bias** error. Bias can occur if, for example, the wrong variables or trend line are used or if a seasonal index is misapplied.

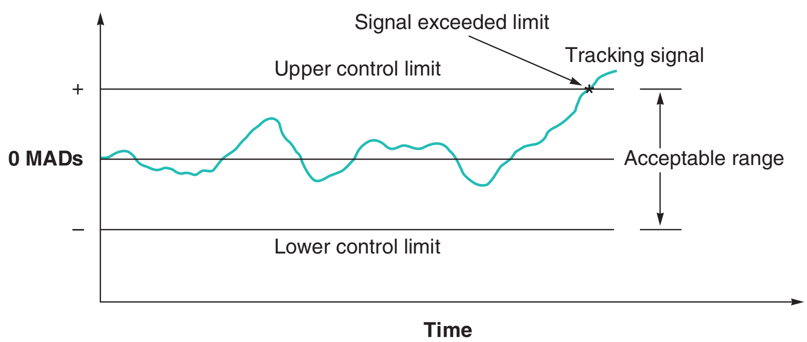
Bias
A forecast that is consistently higher or consistently lower than actual values of a time series.

Once tracking signals are calculated, they are compared with predetermined control limits. When a tracking signal exceeds an upper or lower limit, there is a problem with the forecasting method, and management may want to reevaluate the way it forecasts demand. Figure 4.11 shows the graph of a tracking signal that is exceeding the range of acceptable variation. If the model being used is exponential smoothing, perhaps the smoothing constant needs to be readjusted.

LO 4.7 *Use* a tracking signal

How do firms decide what the upper and lower tracking limits should be? There is no single answer, but they try to find reasonable values—in other words, limits not so low as to be triggered with every small forecast error and not so high as to allow bad forecasts to be regularly overlooked. One MAD is equivalent to approximately .8 standard deviations,

Figure **4.11**
A Plot of Tracking Signals



Bernard Smith, inventory manager for American Hardware Supply, coined the term *focus forecasting*. Smith's job was to forecast quantities for 100,000 hardware products purchased by American's 21 buyers.[4] He found that buyers neither trusted nor understood the exponential smoothing model then in use. Instead, they used very simple approaches of their own. So Smith developed his new computerized system for selecting forecasting methods.

Smith chose to test seven forecasting methods. They ranged from the simple ones that buyers used (such as the naive approach) to statistical models. Every month, Smith applied the forecasts of all seven models to each item in stock. In these simulated trials, the forecast values were subtracted from the most recent actual demands, giving a simulated forecast error. The forecast method yielding the least error is selected by the computer, which then uses it to make next month's forecast. Although buyers still have an override capability, American Hardware finds that focus forecasting provides excellent results.

Forecasting in the Service Sector

STUDENT TIP Forecasting at McDonald's, FedEx, and Walmart is as important and complex as it is for manufacturers such as Toyota and Dell.

Forecasting in the service sector presents some unusual challenges. A major technique in the retail sector is tracking demand by maintaining good short-term records. For instance, a barbershop catering to men expects peak flows on Fridays and Saturdays. Indeed, most barbershops are closed on Sunday and Monday, and many call in extra help on Friday and Saturday. A downtown restaurant, on the other hand, may need to track conventions and holidays for effective short-term forecasting.

Specialty Retail Shops Specialty retail facilities, such as flower shops, may have other unusual demand patterns, and those patterns will differ depending on the holiday. When Valentine's Day falls on a weekend, for example, flowers can't be delivered to offices, and those romantically inclined are likely to celebrate with outings rather than flowers. If a holiday falls on a Monday, some of the celebration may also take place on the weekend, reducing flower sales. However, when Valentine's Day falls in midweek, busy midweek schedules often make flowers the optimal way to celebrate. Because flowers for Mother's Day are to be delivered on Saturday or Sunday, this holiday forecast varies less. Due to special demand patterns, many service firms maintain records of sales, noting not only the day of the week but also unusual events, including the weather, so that patterns and correlations that influence demand can be developed.

VIDEO 4.2 Forecasting at Hard Rock Cafe

Fast-Food Restaurants Fast-food restaurants are well aware not only of weekly, daily, and hourly but even 15-minute variations in demands that influence sales. Therefore, detailed forecasts of demand are needed. Figure 4.12(a) shows the hourly forecast for a typical fast-food restaurant. Note the lunchtime and dinnertime peaks. This contrasts to the mid-morning and mid-afternoon peaks at FedEx's call center in Figure 4.12(b).

Firms like Taco Bell now use point-of-sale computers that track sales every quarter hour. Taco Bell found that a 6-week moving average was the forecasting technique that minimized its mean squared error (MSE) of these quarter-hour forecasts. Building this forecasting methodology into each of Taco Bell's 6,500 U.S. stores' computers, the model makes weekly projections of customer transactions. These in turn are used by store managers to schedule staff, who begin in 15-minute increments, not 1-hour blocks as in other industries. The forecasting model has been so successful that Taco Bell has increased customer service while documenting more than $50 million in labor cost savings in 4 years of use.

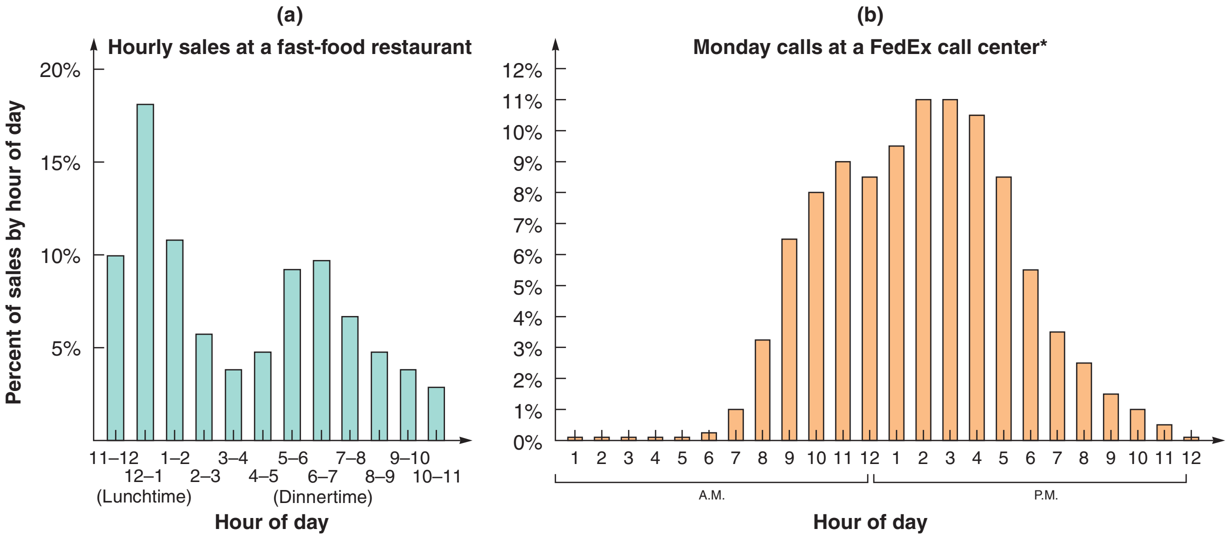


Figure **4.12**

Forecasts Are Unique: Note the Variations between (a) Hourly Sales at a Fast-Food Restaurant and (b) Hourly Call Volume at FedEx

*Based on historical data: see *Journal of Business Forecasting* (Winter 1999–2000): 6–11.

Summary

Forecasts are a critical part of the operations manager's function. Demand forecasts drive a firm's production, capacity, and scheduling systems and affect the financial, marketing, and personnel planning functions.

There are a variety of qualitative and quantitative forecasting techniques. Qualitative approaches employ judgment, experience, intuition, and a host of other factors that are difficult to quantify. Quantitative forecasting uses historical data and causal, or associative, relations to project future demands. The Rapid Review for this chapter summarizes the formulas we introduced in quantitative forecasting. Forecast calculations are seldom performed by hand. Most operations managers turn to software packages such as Forecast PRO, NCSS, Minitab, Systat, Statgraphics, SAS, or SPSS.

No forecasting method is perfect under all conditions. And even once management has found a satisfactory approach, it must still monitor and control forecasts to make sure errors do not get out of hand. Forecasting can often be a very challenging, but rewarding, part of managing.

Key Terms

Forecasting (p. 108)
Economic forecasts (p. 109)
Technological forecasts (p. 109)
Demand forecasts (p. 109)
Quantitative forecasts (p. 111)
Qualitative forecasts (p. 111)
Jury of executive opinion (p. 111)
Delphi method (p. 111)
Sales force composite (p. 111)
Market survey (p. 111)
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Naive approach (p. 114)
Moving averages (p. 114)
Exponential smoothing (p. 116)
Smoothing constant (p. 116)
Mean absolute deviation (MAD) (p. 118)
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Mean absolute percent error (MAPE) (p. 120)
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Cycles (p. 131)
Linear-regression analysis (p. 131)
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Coefficient of correlation (p. 134)
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Focus forecasting (p. 139)

Ethical Dilemma

We live in a society obsessed with test scores and maximum performance. Think of the SAT, ACT, GRE, GMAT, and LSAT. Though they take only a few hours, they are supposed to give schools and companies a snapshot of a student's abiding talents.

But these tests are often spectacularly bad at forecasting performance in the real world. The SAT does a decent job (r^2 = .12) of predicting the grades of a college freshman. It is, however, less effective at predicting achievement *after* graduation. LSAT scores bear virtually no correlation to career success as measured by income, life satisfaction, or public service.

Robert Kneschke/Fotolia

What does the r^2 mean in this context? Is it ethical for colleges to base admissions and financial aid decisions on scores alone? What role do these tests take at your own school?

Discussion Questions

1. What is a qualitative forecasting model, and when is its use appropriate?
2. Identify and briefly describe the two general forecasting approaches.
3. Identify the three forecasting time horizons. State an approximate duration for each.
4. Briefly describe the steps that are used to develop a forecasting system.
5. A skeptical manager asks what medium-range forecasts can be used for. Give the manager three possible uses/purposes.
6. Explain why such forecasting devices as moving averages, weighted moving averages, and exponential smoothing are not well suited for data series that have trends.
7. What is the basic difference between a weighted moving average and exponential smoothing?
8. What three methods are used to determine the accuracy of any given forecasting method? How would you determine whether time-series regression or exponential smoothing is better in a specific application?
9. Research and briefly describe the Delphi technique. How would it be used by an employer you have worked for?
10. What is the primary difference between a time-series model and an associative model?
11. Define *time series*.
12. What effect does the value of the smoothing constant have on the weight given to the recent values?
13. Explain the value of seasonal indices in forecasting. How are seasonal patterns different from cyclical patterns?
14. Which forecasting technique can place the most emphasis on recent values? How does it do this?
15. In your own words, explain adaptive forecasting.
16. What is the purpose of a tracking signal?
17. Explain, in your own words, the meaning of the correlation coefficient. Discuss the meaning of a negative value of the correlation coefficient.
18. What is the difference between a dependent and an independent variable?
19. Give examples of industries that are affected by seasonality. Why would these businesses want to filter out seasonality?
20. Give examples of industries in which demand forecasting is dependent on the demand for other products.
21. What happens to the ability to forecast for periods farther into the future?
22. CEO John Goodale, at Southern Illinois Power and Light, has been collecting data on demand for electric power in its western subregion for only the past 2 years. Those data are shown in the table below.

    To plan for expansion and to arrange to borrow power from neighboring utilities during peak periods, Goodale needs to be able to forecast demand for each month next year. However, the standard forecasting models discussed in this chapter will not fit the data observed for the 2 years.

    a) What are the weaknesses of the standard forecasting techniques as applied to this set of data?
    b) Because known models are not appropriate here, propose your own approach to forecasting. Although there is no perfect solution to tackling data such as these (in other words, there are no 100% right or wrong answers), justify your model.
    c) Forecast demand for each month next year using the model you propose.

DEMAND IN MEGAWATTS		
MONTH	**LAST YEAR**	**THIS YEAR**
January	5	17
February	6	14
March	10	20
April	13	23
May	18	30
June	15	38
July	23	44
August	26	41
September	21	33
October	15	23
November	12	26
December	14	17

Using Software in Forecasting

This section presents three ways to solve forecasting problems with computer software. First, you can create your own Excel spreadsheets to develop forecasts. Second, you can use the Excel OM software that comes with the text. Third, POM for Windows is another program that is located in MyOMLab.

CREATING YOUR OWN EXCEL SPREADSHEETS

Excel spreadsheets (and spreadsheets in general) are frequently used in forecasting. Exponential smoothing, trend analysis, and regression analysis (simple and multiple) are supported by built-in Excel functions.

Program 4.1 illustrates how to build an Excel forecast for the data in Example 8. The goal for N.Y. Edison is to create a trend analysis of the year 1 to year 7 data.

As an alternative, you may want to experiment with Excel's built-in regression analysis. To do so, under the **Data** menu bar selection choose **Data Analysis**, then **Regression**. Enter your *Y* and *X* data into two columns (say A and B). When the regression window appears, enter the *Y* and *X* ranges, then select **OK**. Excel offers several plots and tables to those interested in more rigorous analysis of regression problems.

USING POM FOR WINDOWS

POM for Windows can project moving averages (both simple and weighted), handle exponential smoothing (both simple and trend adjusted), forecast with least squares trend projection, and solve linear regression (associative) models. A summary screen of error analysis and a graph of the data can also be generated. As a special example of exponential smoothing adaptive forecasting, when using an α of 0, POM for Windows will find the α value that yields the minimum MAD.

Appendix IV provides further details.

Solved Problems

Virtual Office Hours help is available in MyOMLab.

SOLVED PROBLEM 4.1

Sales of Volkswagen's popular Beetle have grown steadily at auto dealerships in Nevada during the past 5 years (see table below). The sales manager had predicted before the new model was introduced that first year sales would be 410 VWs. Using exponential smoothing with a weight of $\alpha = .30$, develop forecasts for years 2 through 6.

YEAR	SALES	FORECAST
1	450	410
2	495	
3	518	
4	563	
5	584	
6	?	

SOLUTION

YEAR	FORECAST
1	410.0
2	422.0 = 410 + .3 (450 − 410)
3	443.9 = 422 + .3 (495 − 422)
4	466.1 = 443.9 + .3 (518 − 443.9)
5	495.2 = 466.1 + .3 (563 − 466.1)
6	521.8 = 495.2 + .3 (584 − 495.2)

SOLVED PROBLEM 4.2

In Example 7, we applied trend-adjusted exponential smoothing to forecast demand for a piece of pollution-control equipment for months 2 and 3 (out of 9 months of data provided). Let us now continue this process for month 4. We want to confirm the forecast for month 4 shown in Table 4.2 (p. 123) and Figure 4.3 (p. 123).

For month 4, $A_4 = 19$, with $\alpha = .2$, and $\beta = .4$.

SOLUTION

$$\begin{aligned}
F_4 &= \alpha A_3 + (1 - \alpha)(F_3 + T_3) \\
&= (.2)(20) + (1 - .2)(15.18 + 2.10) \\
&= 4.0 + (.8)(17.28) \\
&= 4.0 + 13.82 \\
&= 17.82 \\
T_4 &= \beta(F_4 - F_3) + (1 - \beta)T_3 \\
&= (.4)(17.82 - 15.18) + (1 - .4)(2.10) \\
&= (.4)(2.64) + (.6)(2.10) \\
&= 1.056 + 1.26 \\
&= 2.32 \\
FIT_4 &= 17.82 + 2.32 \\
&= 20.14
\end{aligned}$$

SOLVED PROBLEM 4.3

Sales of hair dryers at the Walgreens stores in Youngstown, Ohio, over the past 4 months have been 100, 110, 120, and 130 units (with 130 being the most recent sales).

Develop a moving-average forecast for next month, using these three techniques:

a) 3-month moving average.
b) 4-month moving average.
c) Weighted 4-month moving average with the most recent month weighted 4, the preceding month 3, then 2, and the oldest month weighted 1.
d) If next month's sales turn out to be 140 units, forecast the following month's sales (months) using a 4-month moving average.

SOLUTION

a) 3-month moving average

$$= \frac{110 + 120 + 130}{3} = \frac{360}{3} = 120 \text{ dryers}$$

b) 4-month moving average

$$= \frac{100 + 110 + 120 + 130}{4} = \frac{460}{4} = 115 \text{ dryers}$$

c) Weighted moving average

$$= \frac{4(130) + 3(120) + 2(110) + 1(100)}{10}$$

$$= \frac{1{,}200}{10} = 120 \text{ dryers}$$

d) *Now* the four most recent sales are 110, 120, 130, and 140.

$$\text{4-month moving average} = \frac{110 + 120 + 130 + 140}{4} = \frac{500}{4} = 125 \text{ dryers}$$

We note, of course, the lag in the forecasts, as the moving-average method does not immediately recognize trends.

SOLVED PROBLEM 4.7

Cengiz Haksever runs an Istanbul high-end jewelry shop. He advertises weekly in local Turkish newspapers and is thinking of increasing his ad budget. Before doing so, he decides to evaluate the past effectiveness of these ads. Five weeks are sampled, and the data are shown in the table below:

SALES ($1,000s)	AD BUDGET THAT WEEK ($100s)
11	5
6	3
10	7
6	2
12	8

Develop a regression model to help Cengiz evaluate his advertising.

SOLUTION

We apply the least-squares regression model as we did in Example 12.

SALES, y	ADVERTISING, x	x^2	xy
11	5	25	55
6	3	9	18
10	7	49	70
6	2	4	12
12	8	64	96
$\Sigma y = 45$	$\Sigma x = 25$	$\Sigma x^2 = 151$	$\Sigma xy = 251$
$\bar{y} = \frac{45}{5} = 9$	$\bar{x} = \frac{25}{5} = 5$		

$$b = \frac{\Sigma xy - n\bar{x}\bar{y}}{\Sigma x^2 - n\bar{x}^2} = \frac{251 - (5)(5)(9)}{151 - (5)(5^2)}$$

$$= \frac{251 - 225}{151 - 125} = \frac{26}{26} = 1$$

$$a = \bar{y} - b\bar{x} = 9 - (1)(5) = 4$$

So the regression model is $\hat{y} = 4 + 1x$, or

Sales (in \$1,000s) = 4 + 1 (Ad budget in \$100s)

This means that for each 1-unit increase in x (or \$100 in ads), sales increase by 1 unit (or \$1,000).

SOLVED PROBLEM 4.8

Using the data in Solved Problem 4.7, find the coefficient of determination, r^2, for the model.

SOLUTION

To find r^2, we need to also compute Σy^2.

$$\Sigma y^2 = 11^2 + 6^2 + 10^2 + 6^2 + 12^2$$
$$= 121 + 36 + 100 + 36 + 144 = 437$$

The next step is to find the coefficient of correlation, r:

$$r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

$$= \frac{5(251) - (25)(45)}{\sqrt{[5(151) - (25)^2][5(437) - (45)^2]}}$$

$$= \frac{1{,}255 - 1{,}125}{\sqrt{(130)(160)}} = \frac{130}{\sqrt{20{,}800}} = \frac{130}{144.22}$$

$$= .9014$$

Thus, $r^2 = (.9014)^2 = .8125$, meaning that about 81% of the variability in sales can be explained by the regression model with advertising as the independent variable.

Problems

Note: **Px** means the problem may be solved with POM for Windows and/or Excel OM.

Problems 4.1–4.42 relate to Time-Series Forecasting

• **4.1** The following gives the number of pints of type B blood used at Woodlawn Hospital in the past 6 weeks:

WEEK OF	PINTS USED
August 31	360
September 7	389
September 14	410
September 21	381
September 28	368
October 5	374

a) Forecast the demand for the week of October 12 using a 3-week moving average.
b) Use a 3-week weighted moving average, with weights of .1, .3, and .6, using .6 for the most recent week. Forecast demand for the week of October 12.
c) Compute the forecast for the week of October 12 using exponential smoothing with a forecast for August 31 of 360 and $\alpha = .2$. **Px**

•• **4.2**

YEAR	1	2	3	4	5	6	7	8	9	10	11
DEMAND	7	9	5	9	13	8	12	13	9	11	7

a) Plot the above data on a graph. Do you observe any trend, cycles, or random variations?
b) Starting in year 4 and going to year 12, forecast demand using a 3-year moving average. Plot your forecast on the same graph as the original data.

b) Determine the coefficient of correlation and the standard error of the estimate. Px

Additional problems **4.55-4.58** *are available in* MyOMLab.

Problems 4.59–4.61 relate to Monitoring and Controlling Forecasts

• • **4.59** Sales of tablet computers at Ted Glickman's electronics store in Washington, D.C., over the past 10 weeks are shown in the table below:

WEEK	DEMAND	WEEK	DEMAND
1	20	6	29
2	21	7	36
3	28	8	22
4	37	9	25
5	25	10	28

a) Forecast demand for each week, including week 10, using exponential smoothing with $\alpha = .5$ (initial forecast = 20).

b) Compute the MAD.

c) Compute the tracking signal. Px

• • • **4.60** The following are monthly actual and forecast demand levels for May through December for units of a product manufactured by the D. Bishop Company in Des Moines:

MONTH	ACTUAL DEMAND	FORECAST DEMAND
May	100	100
June	80	104
July	110	99
August	115	101
September	105	104
October	110	104
November	125	105
December	120	109

What is the value of the tracking signal as of the end of December?

Additional problem **4.61** *is available in* MyOMLab.

CASE STUDIES

Southwestern University: (B)*

Southwestern University (SWU), a large state college in Stephenville, Texas, enrolls close to 20,000 students. The school is a dominant force in the small city, with more students during fall and spring than permanent residents.

Always a football powerhouse, SWU is usually in the top 20 in college football rankings. Since the legendary Phil Flamm was hired as its head coach in 2009 (in hopes of reaching the elusive number 1 ranking), attendance at the five Saturday home games each year increased. Prior to Flamm's arrival, attendance generally averaged 25,000 to 29,000 per game. Season ticket sales bumped up by 10,000 just with the announcement of the new coach's arrival. Stephenville and SWU were ready to move to the big time!

Southwestern University Football Game Attendance, 2010–2015

	2010		2011		2012	
GAME	ATTENDEES	OPPONENT	ATTENDEES	OPPONENT	ATTENDEES	OPPONENT
1	34,200	Rice	36,100	Miami	35,900	USC
2[a]	39,800	Texas	40,200	Nebraska	46,500	Texas Tech
3	38,200	Duke	39,100	Ohio State	43,100	Alaska
4[b]	26,900	Arkansas	25,300	Nevada	27,900	Arizona
5	35,100	TCU	36,200	Boise State	39,200	Baylor

	2013		2014		2015	
GAME	ATTENDEES	OPPONENT	ATTENDEES	OPPONENT	ATTENDEES	OPPONENT
1	41,900	Arkansas	42,500	Indiana	46,900	LSU
2[a]	46,100	Missouri	48,200	North Texas	50,100	Texas
3	43,900	Florida	44,200	Texas A&M	45,900	South Florida
4[b]	30,100	Central Florida	33,900	Southern	36,300	Montana
5	40,500	LSU	47,800	Oklahoma	49,900	Arizona State

[a] Homecoming games.

[b] During the fourth week of each season, Stephenville hosted a hugely popular southwestern crafts festival. This event brought tens of thousands of tourists to the town, especially on weekends, and had an obvious negative impact on game attendance.

Discussion Questions*

1. Describe three different forecasting applications at Hard Rock. Name three other areas in which you think Hard Rock could use forecasting models.
2. What is the role of the POS system in forecasting at Hard Rock?
3. Justify the use of the weighting system used for evaluating managers for annual bonuses.
4. Name several variables besides those mentioned in the case that could be used as good predictors of daily sales in each cafe.
5. At Hard Rock's Moscow restaurant, the manager is trying to evaluate how a new advertising campaign affects guest counts. Using data for the past 10 months (see the table), develop a least-squares regression relationship and then forecast the expected guest count when advertising is $65,000.

*You may wish to view the video that accompanies this case before answering these questions.

- **Additional Case Studies:** Visit MyOMLab for these free case studies:
  North-South Airlines: Reflects the merger of two airlines and addresses their maintenance costs.
  Digital Cell Phone, Inc.: Uses regression analysis and seasonality to forecast demand at a cell phone manufacturer.

Endnotes

1. For a good review of statistical terms, refer to Tutorial 1, "Statistical Review for Managers," in MyOMLab.
2. When the sample size is large ($n > 30$), the prediction interval value of y can be computed using normal tables. When the number of observations is small, the t-distribution is appropriate. See D. Groebner et al., *Business Statistics*, 9th ed. (Upper Saddle River, NJ: Prentice Hall, 2014).
3. To prove these three percentages to yourself, just set up a normal curve for ± 1.6 standard deviations (z-values). Using the normal table in Appendix I, you find that the area under the curve is .89. This represents ± 2 MADs. Likewise, ± 3 MADs $= \pm 2.4$ standard deviations encompass 98% of the area, and so on for ± 4 MADs.
4. Bernard T. Smith, *Focus Forecasting: Computer Techniques for Inventory Control* (Boston: CBI Publishing, 1978).

Chapter 4 *Rapid* Review

Main Heading	Review Material	MyOMLab
WHAT IS FORECASTING? (pp. 108–109)	■ **Forecasting**—The art and science of predicting future events. ■ **Economic forecasts**—Planning indicators that are valuable in helping organizations prepare medium- to long-range forecasts. ■ **Technological forecasts**—Long-term forecasts concerned with the rates of technological progress. ■ **Demand forecasts**—Projections of a company's sales for each time period in the planning horizon.	Concept Questions: 1.1–1.4
THE STRATEGIC IMPORTANCE OF FORECASTING (pp. 109–110)	*The forecast is the only estimate of demand until actual demand becomes known.* Forecasts of demand drive decisions in many areas, including: human resources, capacity, and supply chain management.	Concept Questions: 2.1–2.3
SEVEN STEPS IN THE FORECASTING SYSTEM (pp. 110–111)	■ Forecasting follows seven basic steps: (1) Determine the use of the forecast; (2) Select the items to be forecasted; (3) Determine the time horizon of the forecast; (4) Select the forecasting model(s); (5) Gather the data needed to make the forecast; (6) Make the forecast; (7) Validate and implement the results.	Concept Questions: 3.1–3.4
FORECASTING APPROACHES (pp. 111–112)	■ **Quantitative forecasts**—Forecasts that employ mathematical modeling to forecast demand. ■ **Qualitative forecast**—Forecasts that incorporate such factors as the decision maker's intuition, emotions, personal experiences, and value system. ■ **Jury of executive opinion**—Takes the opinion of a small group of high-level managers and results in a group estimate of demand. ■ **Delphi method**—Uses an interactive group process that allows experts to make forecasts. ■ **Sales force composite**—Based on salespersons' estimates of expected sales. ■ **Market survey**—Solicits input from customers or potential customers regarding future purchasing plans. ■ **Time series**—Uses a series of past data points to make a forecast.	Concept Questions: 4.1–4.4
TIME-SERIES FORECASTING (pp. 112–131)	■ **Naive approach**—Assumes that demand in the next period is equal to demand in the most recent period. ■ **Moving average**—Uses an average of the n most recent periods of data to forecast the next period. $\text{Moving average} = \frac{\sum \text{demand in previous } n \text{ periods}}{n}$ (4-1) $\text{Weighted moving average} = \frac{\sum((\text{Weight for period } n)(\text{Demand in period } n))}{\sum \text{Weights}}$ (4-2) ■ **Exponential smoothing**—A weighted-moving-average forecasting technique in which data points are weighted by an exponential function. ■ **Smoothing constant**—The weighting factor, α, used in an exponential smoothing forecast, a number between 0 and 1. Exponential smoothing formula: $F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$ (4-4) ■ **Mean absolute deviation (MAD)**—A measure of the overall forecast error for a model. $\text{MAD} = \frac{\sum \lvert \text{Actual} - \text{Forecast} \rvert}{n}$ (4-5) ■ **Mean squared error (MSE)**—The average of the squared differences between the forecast and observed values. $\text{MSE} = \frac{\sum (\text{Forecast errors})^2}{n}$ (4-6) ■ **Mean absolute percent error (MAPE)**—The average of the absolute differences between the forecast and actual values, expressed as a percentage of actual values. $\text{MAPE} = \frac{\sum_{i=1}^{n} 100 \lvert \text{Actual}_i - \text{Forecast}_i \rvert / \text{Actual}_i}{n}$ (4-7)	Concept Questions: 5.1–5.4 Problems: 4.1–4.42 Virtual Office Hours for Solved Problems: 4.1–4.4 ACTIVE MODELS 4.1–4.4

Chapter 4 *Rapid* Review *continued*

Main Heading	Review Material	MyOMLab
	Exponential smoothing with trend adjustment Forecast including trend (FIT_t) = Exponentially smoothed forecast average (F_t) + Exponentially smoothed trend (T_t) (4-8) ■ **Trend projection**—A time-series forecasting method that fits a trend line to a series of historical data points and then projects the line into the future for forecasts. Trend projection and regression analysis $\hat{y} = a + bx$, where $b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2}$ and $a = \bar{y} - b\bar{x}$ (4-11), (4-12), (4-13) ■ **Seasonal variations**—Regular upward or downward movements in a time series that tie to recurring events. ■ **Cycles**—Patterns in the data that occur every several years.	Virtual Office Hours for Solved Problems: 4.5–4.6
ASSOCIATIVE FORECASTING METHODS: REGRESSION AND CORRELATION ANALYSIS (pp. 131–137)	■ **Linear-regression analysis**—A straight-line mathematical model to describe the functional relationships between independent and dependent variables. ■ **Standard error of the estimate**—A measure of variability around the regression line. ■ **Coefficient of correlation**—A measure of the strength of the relationship between two variables. ■ **Coefficient of determination**—A measure of the amount of variation in the dependent variable about its mean that is explained by the regression equation. ■ **Multiple regression**—An associative forecasting method with > 1 independent variable. Multiple regression forecast: $\hat{y} = a + b_1x_1 + b_2x_2$ (4-17)	Concept Questions: 6.1–6.4 Problems: 4.43-4.58 **VIDEO 4.1** Forecasting Ticket Revenue for Orlando Magic Basketball Games Virtual Office Hours for Solved Problems: 4.7–4.8
MONITORING AND CONTROLLING FORECASTS (pp. 138–140)	■ **Tracking signal**—A measurement of how well the forecast is predicting actual values. $\text{Tracking signal} = \frac{\sum(\text{Actual demand in period } i - \text{Forecast demand in period } i)}{\text{MAD}}$ (4-18) ■ **Bias**—A forecast that is consistently higher or lower than actual values of a time series. ■ **Adaptive smoothing**—An approach to exponential smoothing forecasting in which the smoothing constant is automatically changed to keep errors to a minimum. ■ **Focus forecasting**—Forecasting that tries a variety of computer models and selects the best one for a particular application.	Concept Questions: 7.1–7.4 Problems: 4.59–4.61
FORECASTING IN THE SERVICE SECTOR (pp. 140–141)	Service-sector forecasting may require good short-term demand records, even per 15-minute intervals. Demand during holidays or specific weather events may also need to be tracked.	Concept Question: 8.1 **VIDEO 4.2** Forecasting at Hard Rock Cafe

Self Test

■ **Before taking the self-test,** refer to the learning objectives listed at the beginning of the chapter and the key terms listed at the end of the chapter.

LO 4.1 Forecasting time horizons include:
a) long range. b) medium range.
c) short range. d) all of the above.

LO 4.2 Qualitative methods of forecasting include:
a) sales force composite. b) jury of executive opinion.
c) consumer market survey. d) exponential smoothing.
e) all except (d).

LO 4.3 The difference between a *moving-average* model and an *exponential smoothing* model is that ______.

LO 4.4 Three popular measures of forecast accuracy are:
a) total error, average error, and mean error.
b) average error, median error, and maximum error.
c) median error, minimum error, and maximum absolute error.
d) mean absolute deviation, mean squared error, and mean absolute percent error.

LO 4.5 Average demand for iPods in the Rome, Italy, Apple store is 800 units per month. The May monthly index is 1.25. What is the seasonally adjusted sales forecast for May?
a) 640 units b) 798.75 units
c) 800 units d) 1,000 units
e) cannot be calculated with the information given

LO 4.6 The main difference between simple and multiple regression is ______.

LO 4.7 The tracking signal is the:
a) standard error of the estimate.
b) cumulative error.
c) mean absolute deviation (MAD).
d) ratio of the cumulative error to MAD.
e) mean absolute percent error (MAPE).

Answers: LO 4.1. d; LO 4.2. e; LO 4.3. exponential smoothing is a weighted moving-average model in which all prior values are weighted with a set of exponentially declining weights; LO 4.4. d; LO 4.5. d; LO 4.6. simple regression has only one independent variable; LO 4.7. d.