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Essentials of Modern Business Statistics

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Essentials of Modern Business Statistics 8e

with Microsoft® Excel®

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***Essentials of Modern Business Statistics with Microsoft® Excel®*, 8e**
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Preface

This text is the eight edition of *Essentials of Modern Business Statistics with Microsoft® Excel®*. With this edition we welcome two eminent scholars to our author team: Michael J. Fry of the University of Cincinnati and Jeffrey W. Ohlmann of the University of Iowa. Both Mike and Jeff are accomplished teachers, researchers, and practitioners in the fields of statistics and business analytics. You can read more about their accomplishments in the About the Authors section that follows this preface. We believe that the addition of Mike and Jeff as our coauthors will both maintain and improve the effectiveness of *Essentials of Modern Business Statistics with Microsoft Excel*.

The purpose of *Essentials of Modern Business Statistics with Microsoft Excel* is to give students, primarily those in the fields of business administration and economics, a conceptual introduction to the field of statistics and its many applications. The text is applications oriented and written with the needs of the nonmathematician in mind; the mathematical prerequisite is knowledge of algebra.

Applications of data analysis and statistical methodology are an integral part of the organization and presentation of the text material. The discussion and development of each technique is presented in an applications setting, with the statistical results providing insights to decisions and solutions to applied problems.

Although the book is applications oriented, we have taken care to provide sound methodological development and to use notation that is generally accepted for the topic being covered. Hence, students will find that this text provides good preparation for the study of more advanced statistical material. A bibliography to guide further study is included as an appendix.

Use of Microsoft Excel for Statistical Analysis

Essentials of Modern Business Statistics with Microsoft Excel is first and foremost a statistics textbook that emphasizes statistical concepts and applications. But since most practical problems are too large to be solved using hand calculations, some type of statistical software package is required to solve these problems. There are several excellent statistical packages available today. However, because most students and potential employers value spreadsheet experience, many schools now use a spreadsheet package in their statistics courses. Microsoft Excel is the most widely used spreadsheet package in business as well as in colleges and universities. We have written *Essentials of Modern Business Statistics with Microsoft Excel* especially for statistics courses in which Microsoft Excel is used as the software package.

Excel has been integrated within each of the chapters and plays an integral part in providing an application orientation. Although we assume that readers using this text are familiar with Excel basics such as selecting cells, entering formulas, and copying we do not assume that readers are familiar with Excel or Excel's tools for statistical analysis. As a result, we have included Appendix E, which provides an introduction to Excel and tools for statistical analysis.

Throughout the text the discussion of using Excel to perform a statistical procedure appears in a subsection immediately following the discussion of the statistical procedure. We believe that this style enables us to fully integrate the use of Excel throughout the text, but still maintain the primary emphasis on the statistical methodology being discussed. In each of these subsections, we use a standard format for using Excel for statistical analysis. There are four primary tasks: Enter/Access Data, Enter Functions and Formulas, Apply Tools, and Editing Options. We believe a consistent framework for applying Excel helps users to focus on the statistical methodology without getting bogged down in the details of using Excel.

In presenting worksheet figures we often use a nested approach in which the worksheet shown in the background of the figure displays the formulas and the worksheet shown in the foreground shows the values computed using the formulas. Different colors and shades of colors are used to differentiate worksheet cells containing data, highlight cells containing

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Excel functions and formulas, and highlight material printed by Excel as a result of using one or more data analysis tools.

Changes in the Eighth Edition

We appreciate the acceptance and positive response to the previous editions of *Essentials of Modern Business Statistics with Microsoft Excel*. Accordingly, in making modifications for this new edition, we have maintained the presentation style and readability of those editions. The significant changes in the new edition are summarized here.

- **Software.** In addition to step-by-step instructions and screen captures that show how to use the latest version of Excel to implement statistical procedures, we also provide instructions for Excel Online and R through the MindTap Reader.
- **New Examples and Exercises Based on Real Data.** In this edition, we have added headers to all Applications exercises to make the application of each exercise more clear. We have also added over 160 new examples and exercises based on real data and referenced sources. By using data from sources also used by *The Wall Street Journal*, *USA Today*, *The Financial Times*, *Forbes*, and others, we have drawn from actual studies and applications to develop explanations and create exercises that demonstrate the many uses of statistics in business and economics. We believe that the use of real data from interesting and relevant problems generates greater student interest in the material and enables the student to more effectively learn about both statistical methodology and its application.
- **Case Problems.** We have added four new case problems to this edition. The 47 case problems in the text provide students with the opportunity to analyze somewhat larger data sets and prepare managerial reports based on the results of their analysis.
- **Appendixes for Use of R.** We now provide appendixes in the MindTap Reader for many chapters that demonstrate the use of the popular open-source software R and RStudio for statistical applications. The use of R is not required to solve any problems or cases in the textbook, but the appendixes provide an introduction to R and RStudio for interested instructors and students.

Features and Pedagogy

Authors Anderson, Sweeney, Williams, Camm, Cochran, Fry, and Ohlmann have continued many of the features that appeared in previous editions. Important ones for students are noted here.

Methods Exercises and Applications Exercises

The end-of-section exercises are split into two parts, Methods and Applications. The Methods exercises require students to use the formulas and make the necessary computations. The Applications exercises require students to use the chapter material in real-world situations. Thus, students first focus on the computational "nuts and bolts" and then move on to the subtleties of statistical application and interpretation.

Margin Annotations and Notes and Comments

Margin annotations that highlight key points and provide additional insights for the student are a key feature of this text. These annotations, which appear in the margins, are designed to provide emphasis and enhance understanding of the terms and concepts being presented in the text.

At the end of many sections, we provide Notes and Comments designed to give the student additional insights about the statistical methodology and its application. Notes and Comments include warnings about or limitations of the methodology, recommendations for application, brief descriptions of additional technical considerations, and other matters.

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Data Files Accompany the Text

Over 250 data files are available on the website that accompanies the text. DATAfile logos are used in the text to identify the data sets that are available on the website. Data sets for all case problems as well as data sets for larger exercises are included.

MindTap

MindTap, featuring all new Excel Online integration powered by Microsoft, is a complete digital solution for the business statistics course. It has enhancements that take students from learning basic statistical concepts to actively engaging in critical thinking applications, while learning valuable software skills for their future careers. The R appendixes for many of the chapters in the text are also accessible through MindTap.

MindTap is a customizable digital course solution that includes an interactive eBook and autograded, algorithmic exercises from the textbook. All of these materials offer students better access to understand the materials within the course. For more information on MindTap, please contact your Cengage representative.

For Students

Online resources are available to help the student work more efficiently. The resources can be accessed at www.cengage.com/decisionsciences/anderson/embs/8e.

For Instructors

Instructor resources are available to adopters on the Instructor Companion Site, which can be found and accessed at www.cengage.com/decisionsciences/anderson/embs/8e, including:

- **Solutions Manual:** The Solutions Manual, prepared by the authors, includes solutions for all problems in the text. It is available online as well as print.
- **Solutions to Case Problems:** These are also prepared by the authors and contain solutions to all case problems presented in the text.
- **PowerPoint Presentation Slides:** The presentation slides contain a teaching outline that incorporates figures to complement instructor lectures.
- **Test Bank:** Cengage Learning Testing Powered by Cognero is a flexible, online system that allows you to:
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are in applying analytics to the areas of supply chain management, sports, and public-policy operations. He has worked with many different organizations for his research, including Dell, Inc., Starbucks Coffee Company, Great American Insurance Group, the Cincinnati Fire Department, the State of Ohio Election Commission, the Cincinnati Bengals, and the Cincinnati Zoo & Botanical Garden. He was named a finalist for the Daniel H. Wagner Prize for Excellence in Operations Research Practice, and he has been recognized for both his research and teaching excellence at the University of Cincinnati. In 2019 he led the team that was awarded the INFORMS UPS George D. Smith Prize on behalf of the OBAIS Department at the University of Cincinnati.

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Professor Ohlmann's research on the modeling and solution of decision-making problems has produced more than two dozen research papers in journals such as *Operations Research*, *Mathematics of Operations Research*, *INFORMS Journal on Computing*, *Transportation Science*, and *European Journal of Operational Research*. He has collaborated with companies such as Transfreight, LeanCor, Cargill, the Hamilton County Board of Elections, and three National Football League franchises. Because of the relevance of his work to industry, he was bestowed the George B. Dantzig Dissertation Award and was recognized as a finalist for the Daniel H. Wagner Prize for Excellence in Operations Research Practice.

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Chapter 1

Data and Statistics

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STATISTICS IN PRACTICE

Bloomberg Businessweek*

NEW YORK, NEW YORK

Bloomberg Businessweek is one of the most widely read business magazines in the world. Along with feature articles on current topics, the magazine contains articles on international business, economic analysis, information processing, and science and technology. Information in the feature articles and the regular sections helps readers stay abreast of current developments and assess the impact of those developments on business and economic conditions.

Most issues of *Bloomberg Businessweek* provide an in-depth report on a topic of current interest. Often, the in-depth reports contain statistical facts and summaries that help the reader understand the business and economic information. Examples of articles and reports include the impact of businesses moving important work to cloud computing, the crisis facing the U.S. Postal Service, and why the debt crisis is even worse than we think. In addition, *Bloomberg Businessweek* provides a variety of statistics about the state of the economy, including production indexes, stock prices, mutual funds, and interest rates.

Bloomberg Businessweek also uses statistics and statistical information in managing its own business. For example, an annual survey of subscribers helps the company learn about subscriber demographics, reading habits, likely purchases, lifestyles, and so on. *Bloomberg Businessweek* managers use statistical summaries from the survey to provide better services to subscribers and advertisers. One North American subscriber survey indicated that 64% of *Bloomberg Businessweek* subscribers are involved with computer purchases at work. Such statistics alert *Bloomberg Businessweek* managers to subscriber interest in articles about new developments in computers. The results of the subscriber survey are also made available to potential advertisers. The high percentage of subscribers involved with computer purchases at work would be an incentive for a computer manufacturer to consider advertising in *Bloomberg Businessweek.*

In this chapter, we discuss the types of data available for statistical analysis and describe how the data are obtained. We introduce descriptive statistics and statistical inference as ways of converting data into meaningful and easily interpreted statistical information.

Bloomberg Businessweek *uses statistical facts and summaries in many of its articles. AP Images/Weng lei-Imaginechina*

*The authors are indebted to Charlene Trentham, Research Manager, for providing this Statistics in Practice.

Frequently, we see the following types of statements in newspapers and magazines:

- Unemployment dropped to an 18-year low of 3.8% in May 2018 from 3.9% in April and after holding at 4.1% for the prior six months (*Wall Street Journal,* June 1, 2018).
- Tesla ended 2017 with around $5.4 billion of liquidity. Analysts forecast it will burn through $2.8 billion of cash this year (*Bloomberg Businessweek,* April 19, 2018).
- The biggest banks in America reported a good set of earnings for the first three months of 2018. Bank of America and Morgan Stanley made quarterly net profits of $6.9 billion and $2.7 billion, respectively (*The Economist,* April 21, 2018).
- According to a study from the Pew Research Center, 15% of U.S. adults say they have used online dating sites or mobile apps (*Wall Street Journal,* May 2, 2018).

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- According to the U.S. Centers for Disease Control and Prevention, in the United States alone, at least 2 million illnesses and 23,000 deaths can be attributed each year to antibiotic-resistant bacteria (*Wall Street Journal,* February 13, 2018).

The numerical facts in the preceding statements—3.8%, 3.9%, 4.1%, $5.4 billion, $2.8 billion, $6.9 billion, $2.7 billion, 15%, 2 million, 23,000—are called **statistics**. In this usage, the term *statistics* refers to numerical facts such as averages, medians, percentages, and maximums that help us understand a variety of business and economic situations. However, as you will see, the subject of statistics involves much more than numerical facts. In a broader sense, statistics is the art and science of collecting, analyzing, presenting, and interpreting data. Particularly in business and economics, the information provided by collecting, analyzing, presenting, and interpreting data gives managers and decision makers a better understanding of the business and economic environment and thus enables them to make more informed and better decisions. In this text, we emphasize the use of statistics for business and economic decision making.

Chapter 1 begins with some illustrations of the applications of statistics in business and economics. In Section 1.2 we define the term *data* and introduce the concept of a data set. This section also introduces key terms such as *variables* and *observations,* discusses the difference between quantitative and categorical data, and illustrates the uses of cross-sectional and time series data. Section 1.3 discusses how data can be obtained from existing sources or through survey and experimental studies designed to obtain new data. The uses of data in developing descriptive statistics and in making statistical inferences are described in Sections 1.4 and 1.5. The last four sections of Chapter 1 provide the role of the computer in statistical analysis, an introduction to business analytics and the role statistics plays in it, an introduction to big data and data mining, and a discussion of ethical guidelines for statistical practice.

1.1 Applications in Business and Economics

In today's global business and economic environment, anyone can access vast amounts of statistical information. The most successful managers and decision makers understand the information and know how to use it effectively. In this section, we provide examples that illustrate some of the uses of statistics in business and economics.

Accounting

Public accounting firms use statistical sampling procedures when conducting audits for their clients. For instance, suppose an accounting firm wants to determine whether the amount of accounts receivable shown on a client's balance sheet fairly represents the actual amount of accounts receivable. Usually the large number of individual accounts receivable makes reviewing and validating every account too time-consuming and expensive. As common practice in such situations, the audit staff selects a subset of the accounts called a sample. After reviewing the accuracy of the sampled accounts, the auditors draw a conclusion as to whether the accounts receivable amount shown on the client's balance sheet is acceptable.

Finance

Financial analysts use a variety of statistical information to guide their investment recommendations. In the case of stocks, analysts review financial data such as price/earnings ratios and dividend yields. By comparing the information for an individual stock with information about the stock market averages, an analyst can begin to draw a conclusion as to whether the stock is a good investment. For example, the average dividend yield for the S&P 500 companies for 2017 was 1.88%. Over the same period the average dividend yield for Microsoft was 1.72% (*Yahoo Finance*). In this case, the statistical information on dividend yield indicates a lower dividend yield for Microsoft

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than the average dividend yield for the S&P 500 companies. This and other information about Microsoft would help the analyst make an informed buy, sell, or hold recommendation for Microsoft stock.

Marketing

Electronic scanners at retail checkout counters collect data for a variety of marketing research applications. For example, data suppliers such as The Nielsen Company and IRI purchase point-of-sale scanner data from grocery stores, process the data, and then sell statistical summaries of the data to manufacturers. Manufacturers spend hundreds of thousands of dollars per product category to obtain this type of scanner data. Manufacturers also purchase data and statistical summaries on promotional activities such as special pricing and the use of in-store displays. Brand managers can review the scanner statistics and the promotional activity statistics to gain a better understanding of the relationship between promotional activities and sales. Such analyses often prove helpful in establishing future marketing strategies for the various products.

Production

Today's emphasis on quality makes quality control an important application of statistics in production. A variety of statistical quality control charts are used to monitor the output of a production process. In particular, an x-bar chart can be used to monitor the average output. Suppose, for example, that a machine fills containers with 12 ounces of a soft drink. Periodically, a production worker selects a sample of containers and computes the average number of ounces in the sample. This average, or x-bar value, is plotted on an x-bar chart. A plotted value above the chart's upper control limit indicates overfilling, and a plotted value below the chart's lower control limit indicates underfilling. The process is termed "in control" and allowed to continue as long as the plotted x-bar values fall between the chart's upper and lower control limits. Properly interpreted, an x-bar chart can help determine when adjustments are necessary to correct a production process.

Economics

Economists frequently provide forecasts about the future of the economy or some aspect of it. They use a variety of statistical information in making such forecasts. For instance, in forecasting inflation rates, economists use statistical information on such indicators as the Producer Price Index, the unemployment rate, and manufacturing capacity utilization. Often these statistical indicators are entered into computerized forecasting models that predict inflation rates.

Information Systems

Information systems administrators are responsible for the day-to-day operation of an organization's computer networks. A variety of statistical information helps administrators assess the performance of computer networks, including local area networks (LANs), wide area networks (WANs), network segments, intranets, and other data communication systems. Statistics such as the mean number of users on the system, the proportion of time any component of the system is down, and the proportion of bandwidth utilized at various times of the day, are examples of statistical information that help the system administrator better understand and manage the computer network.

Applications of statistics such as those described in this section are an integral part of this text. Such examples provide an overview of the breadth of statistical applications. To supplement these examples, practitioners in the fields of business and economics provided chapter-opening Statistics in Practice articles that introduce the material covered in each chapter. The Statistics in Practice applications show the importance of statistics in a wide variety of business and economic situations.

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1.2 Data

Data are the facts and figures collected, analyzed, and summarized for presentation and interpretation. All the data collected in a particular study are referred to as the **data set** for the study. Table 1.1 shows a data set containing information for 60 nations that participate in the World Trade Organization (WTO). The WTO encourages the free flow of international trade and provides a forum for resolving trade disputes.

Elements, Variables, and Observations

Elements are the entities on which data are collected. Each nation listed in Table 1.1 is an element with the nation or element name shown in the first column. With 60 nations, the data set contains 60 elements.

A **variable** is a characteristic of interest for the elements. The data set in Table 1.1 includes the following five variables:

- WTO Status: The nation's membership status in the World Trade Organization; this can be either as a member or as an observer.
- Per Capita Gross Domestic Product (GDP) ($): The total market value ($) of all goods and services produced by the nation divided by the number of people in the nation; this is commonly used to compare economic productivity of the nations.
- Fitch Rating: The nation's sovereign credit rating as appraised by the Fitch Group[1]; the credit ratings range from a high of AAA to a low of F and can be modified by + or −.
- Fitch Outlook: An indication of the direction the credit rating is likely to move over the upcoming two years; the outlook can be negative, stable, or positive.

Measurements collected on each variable for every element in a study provide the data. The set of measurements obtained for a particular element is called an **observation**. Referring to Table 1.1, we see that the first observation contains the following measurements: Member, 3615, BB–, and Stable. The second observation contains the following measurements: Member, 49755, AAA, Stable, and so on. A data set with 60 elements contains 60 observations.

Scales of Measurement

Data collection requires one of the following scales of measurement: nominal, ordinal, interval, or ratio. The scale of measurement determines the amount of information contained in the data and indicates the most appropriate data summarization and statistical analyses.

When the data for a variable consist of labels or names used to identify an attribute of the element, the scale of measurement is considered a **nominal scale**. For example, referring to the data in Table 1.1, the scale of measurement for the WTO Status variable is nominal because the data "member" and "observer" are labels used to identify the status category for the nation. In cases where the scale of measurement is nominal, a numerical code as well as a nonnumerical label may be used. For example, to facilitate data collection and to prepare the data for entry into a computer database, we might use a numerical code for the WTO Status variable by letting 1 denote a member nation in the World Trade Organization and 2 denote an observer nation. The scale of measurement is nominal even though the data appear as numerical values.

The scale of measurement for a variable is considered an **ordinal scale** if the data exhibit the properties of nominal data and in addition, the order or rank of the data is meaningful. For example, referring to the data in Table 1.1, the scale of measurement for the Fitch Rating is ordinal, because the rating labels which range from AAA to F can be rank ordered from best credit rating AAA to poorest credit rating F. The rating letters provide

[1]The Fitch Group is one of three nationally recognized statistical rating organizations designated by the U.S. Securities and Exchange Commission. The other two are Standard and Poor's and Moody's investor service.

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DATA*file*
Nations

Data sets such as Nations *are available on the companion site for this title.*

TABLE 1.1 Data Set for 60 Nations in the World Trade Organization

Nation	WTO Status	Per Capita GDP ($)	Fitch Rating	Fitch Outlook
Armenia	Member	3,615	BB−	Stable
Australia	Member	49,755	AAA	Stable
Austria	Member	44,758	AAA	Stable
Azerbaijan	Observer	3,879	BBB−	Stable
Bahrain	Member	22,579	BBB	Stable
Belgium	Member	41,271	AA	Stable
Brazil	Member	8,650	BBB	Stable
Bulgaria	Member	7,469	BBB−	Stable
Canada	Member	42,349	AAA	Stable
Cape Verde	Member	2,998	B+	Stable
Chile	Member	13,793	A+	Stable
China	Member	8,123	A+	Stable
Colombia	Member	5,806	BBB−	Stable
Costa Rica	Member	11,825	BB+	Stable
Croatia	Member	12,149	BBB−	Negative
Cyprus	Member	23,541	B	Negative
Czech Republic	Member	18,484	A+	Stable
Denmark	Member	53,579	AAA	Stable
Ecuador	Member	6,019	B−	Positive
Egypt	Member	3,478	B	Negative
El Salvador	Member	4,224	BB	Negative
Estonia	Member	17,737	A+	Stable
France	Member	36,857	AAA	Negative
Georgia	Member	3,866	BB−	Stable
Germany	Member	42,161	AAA	Stable
Hungary	Member	12,820	BB+	Stable
Iceland	Member	60,530	BBB	Stable
Ireland	Member	64,175	BBB+	Stable
Israel	Member	37,181	A	Stable
Italy	Member	30,669	A−	Negative
Japan	Member	38,972	A+	Negative
Kazakhstan	Observer	7,715	BBB+	Stable
Kenya	Member	1,455	B+	Stable
Latvia	Member	14,071	BBB	Positive
Lebanon	Observer	8,257	B	Stable
Lithuania	Member	14,913	BBB	Stable
Malaysia	Member	9,508	A−	Stable
Mexico	Member	8,209	BBB	Stable
Peru	Member	6,049	BBB	Stable
Philippines	Member	2,951	BB+	Stable
Poland	Member	12,414	A−	Positive
Portugal	Member	19,872	BB+	Negative
South Korea	Member	27,539	AA−	Stable
Romania	Member	9,523	BBB−	Stable
Russia	Member	8,748	BBB	Stable
Rwanda	Member	703	B	Stable
Serbia	Observer	5,426	BB−	Negative
Singapore	Member	52,962	AAA	Stable
Slovakia	Member	16,530	A+	Stable

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Slovenia	Member	21,650	A−	Negative
South Africa	Member	5,275	BBB	Stable
Spain	Member	26,617	A−	Stable
Sweden	Member	51,845	AAA	Stable
Switzerland	Member	79,888	AAA	Stable
Thailand	Member	5,911	BBB	Stable
Turkey	Member	10,863	BBB−	Stable
United Kingdom	Member	40,412	AAA	Negative
United States	Member	57,638	AAA	Stable
Uruguay	Member	15,221	BB+	Positive
Zambia	Member	1,270	B+	Negative

the labels similar to nominal data, but in addition, the data can also be ranked or ordered based on the credit rating, which makes the measurement scale ordinal. Ordinal data can also be recorded by a numerical code, for example, your class rank in school.

The scale of measurement for a variable is an **interval scale** if the data have all the properties of ordinal data and the interval between values is expressed in terms of a fixed unit of measure. Interval data are always numeric. College admission SAT scores are an example of interval-scaled data. For example, three students with SAT math scores of 620, 550, and 470 can be ranked or ordered in terms of best performance to poorest performance in math. In addition, the differences between the scores are meaningful. For instance, student 1 scored $620 - 550 = 70$ points more than student 2, while student 2 scored $550 - 470 = 80$ points more than student 3.

The scale of measurement for a variable is a **ratio scale** if the data have all the properties of interval data and the ratio of two values is meaningful. Variables such as distance, height, weight, and time use the ratio scale of measurement. This scale requires that a zero value be included to indicate that nothing exists for the variable at the zero point. For example, consider the cost of an automobile. A zero value for the cost would indicate that the automobile has no cost and is free. In addition, if we compare the cost of $30,000 for one automobile to the cost of $15,000 for a second automobile, the ratio property shows that the first automobile is $30,000/$15,000 = 2 times, or twice, the cost of the second automobile.

Categorical and Quantitative Data

Data can be classified as either categorical or quantitative. Data that can be grouped by specific categories are referred to as **categorical data**. Categorical data use either the nominal or ordinal scale of measurement. Data that use numeric values to indicate how much or how many are referred to as **quantitative data**. Quantitative data are obtained using either the interval or ratio scale of measurement.

The statistical method appropriate for summarizing data depends upon whether the data are categorical or quantitative.

A **categorical variable** is a variable with categorical data, and a **quantitative variable** is a variable with quantitative data. The statistical analysis appropriate for a particular variable depends upon whether the variable is categorical or quantitative. If the variable is categorical, the statistical analysis is limited. We can summarize categorical data by counting the number of observations in each category or by computing the proportion of the observations in each category. However, even when the categorical data are identified by a numerical code, arithmetic operations such as addition, subtraction, multiplication, and division do not provide meaningful results. Section 2.1 discusses ways of summarizing categorical data.

Arithmetic operations provide meaningful results for quantitative variables. For example, quantitative data may be added and then divided by the number of observations to compute the average value. This average is usually meaningful and easily interpreted. In

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general, more alternatives for statistical analysis are possible when data are quantitative. Section 2.2 and Chapter 3 provide ways of summarizing quantitative data.

Cross-Sectional and Time Series Data

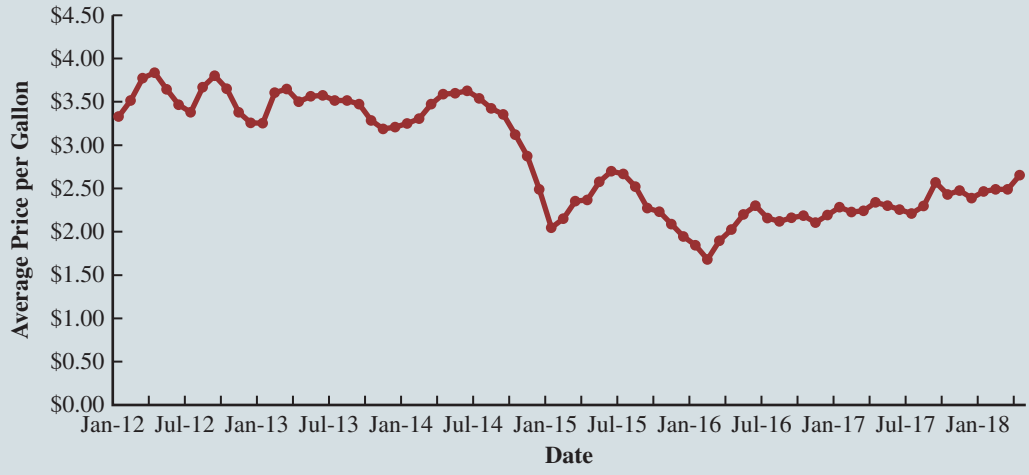
For purposes of statistical analysis, distinguishing between cross-sectional data and time series data is important. **Cross-sectional data** are data collected at the same or approximately the same point in time. The data in Table 1.1 are cross-sectional because they describe the five variables for the 60 World Trade Organization nations at the same point in time. **Time series data** are data collected over several time periods. For example, the time series in Figure 1.1 shows the U.S. average price per gallon of conventional regular gasoline between 2012 and 2018. From January 2012 until June 2014, prices fluctuated between $3.19 and $3.84 per gallon before a long stretch of decreasing prices from July 2014 to January 2015. The lowest average price per gallon occurred in January 2016 ($1.68). Since then, the average price appears to be on a gradual increasing trend.

Graphs of time series data are frequently found in business and economic publications. Such graphs help analysts understand what happened in the past, identify any trends over time, and project future values for the time series. The graphs of time series data can take on a variety of forms, as shown in Figure 1.2. With a little study, these graphs are usually easy to understand and interpret. For example, Panel (A) in Figure 1.2 is a graph that shows the Dow Jones Industrial Average Index from 2008 to 2018. Poor economic conditions caused a serious drop in the index during 2008 with the low point occurring in February 2009 (7,062). After that, the index has been on a remarkable nine-year increase, reaching its peak (26,149) in January 2018.

The graph in Panel (B) shows the net income of McDonald's Inc. from 2008 to 2017. The declining economic conditions in 2008 and 2009 were actually beneficial to McDonald's as the company's net income rose to all-time highs. The growth in McDonald's net income showed that the company was thriving during the economic downturn as people were cutting back on the more expensive sit-down restaurants and seeking less-expensive alternatives offered by McDonald's. McDonald's net income continued to new all-time highs in 2010 and 2011, decreased slightly in 2012, and peaked in 2013. After three years of relatively lower net income, their net income increased to $5.19 billion in 2017.

Panel (C) shows the time series for the occupancy rate of hotels in South Florida over a one-year period. The highest occupancy rates, 95% and 98%, occur during the months

FIGURE 1.1 U.S. Average Price per Gallon for Conventional Regular Gasoline



Source: *Energy Information Administration, U.S. Department of Energy.*

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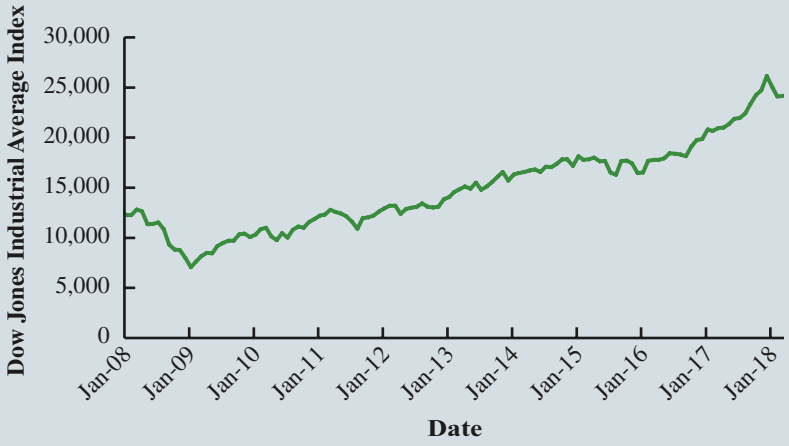
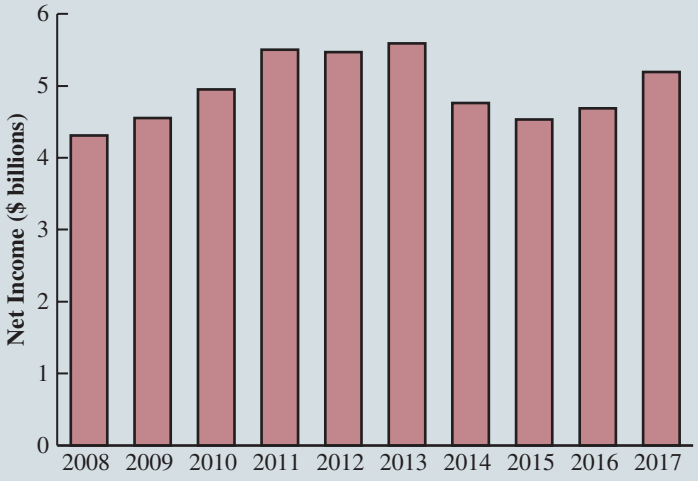
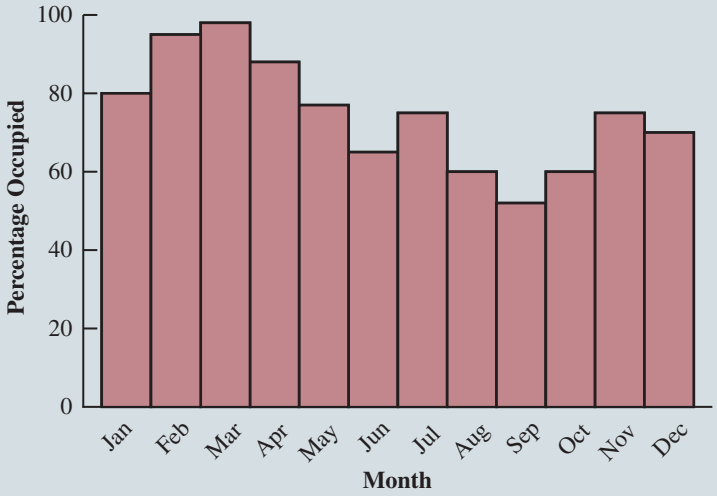
FIGURE 1.2 A Variety of Graphs of Time Series Data



(A) Dow Jones Industrial Average Index



(B) Net Income for McDonald's Inc.



(C) Occupancy Rate of South Florida Hotels

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