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Business Statistics in Practice

Bruce L. Bowerman
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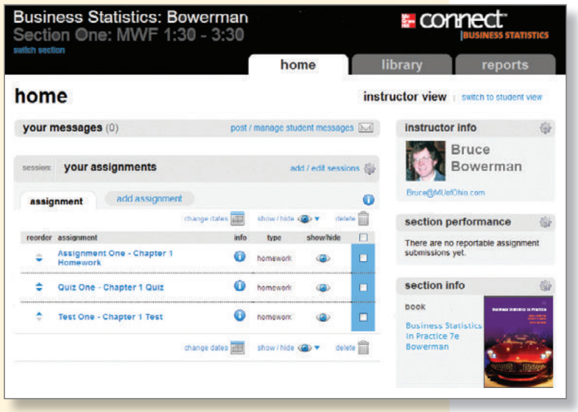

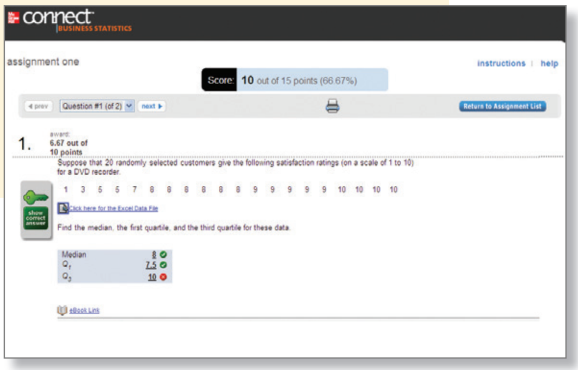

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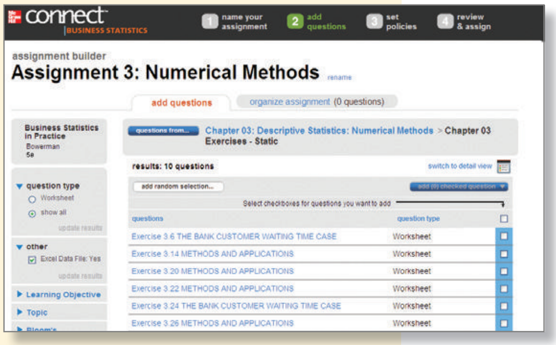

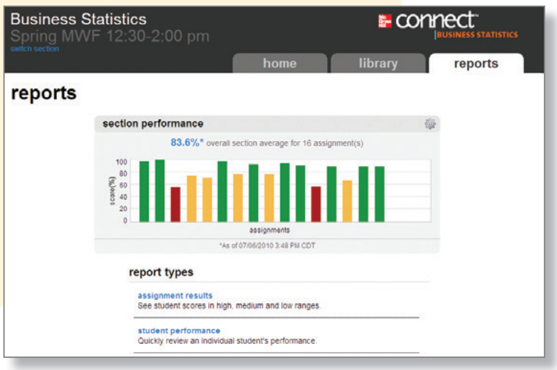

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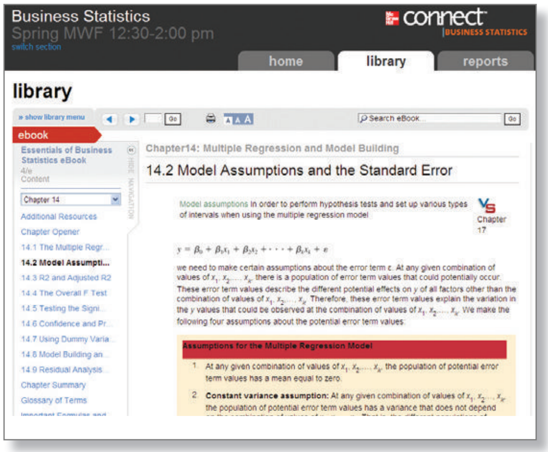

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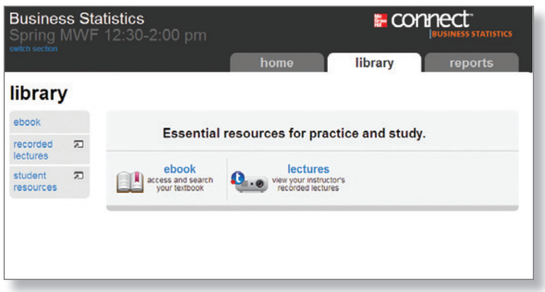

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Business Statistics in Practice

SEVENTH EDITION

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Richard T. O'Connell Richard T. O'Connell is emeritus professor of decision sciences at Miami University in Oxford, Ohio. He has more than 35 years of experience teaching basic statistics, statistical quality control and process improvement, regression analysis, time series forecasting, and design of experiments to both undergraduate and graduate business students. He also has extensive consulting experience and has taught workshops dealing with statistical process control and process improvement for a variety of companies in the Midwest. In 2000 Professor O'Connell received an Effective Educator award from the Richard T. Farmer School of Business Administration. Together with Bruce L. Bowerman, he has written 19 textbooks. These include *Forecasting and Time Series: An Applied Approach; Forecasting, Time Series, and Regression: An Applied Approach* (also coauthored with Anne B. Koehler); and *Linear Statistical Models: An Applied Approach.* Professor O'Connell has published a number of articles in the area of innovative statistical education. He is one of the first college instructors in the United States to integrate statistical process control and process improvement methodology into his basic business statistics course. He (with Professor Bowerman) has written several articles advocating this approach. He has also given presentations on this subject at meetings such as the Joint Statistical Meetings of the American Statistical Association and the Workshop on Total Quality Management: Developing Curricula and Research Agendas (sponsored by the Production and Operations Management Society). Professor O'Connell received an M.S. degree in decision sciences from Northwestern University in 1973, and he is currently a member of both the Decision Sciences Institute and the American Statistical Association. In his spare time, Professor O'Connell enjoys fishing, collecting 1950s and 1960s rock music, and following the Green Bay Packers and Purdue University sports.

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FROM THE

In *Business Statistics in Practice, Seventh Edition,* we provide a modern, practical, and unique framework for teaching an introductory course in business statistics. As in previous editions, we employ real or realistic examples, continuing case studies, and a business improvement theme to teach the material. Moreover, we believe that this seventh edition features more concise and lucid explanations, an improved topic flow, and a judicious use of realistic and compelling examples. Overall, the seventh edition is 80 pages shorter than the sixth edition while covering all previous material as well as additional topics. Below we outline the attributes and new features we think make this book an effective learning tool.

- **Continuing case studies that tie together different statistical topics.** These continuing case studies span not only individual chapters but also groups of chapters. Students tell us that when new statistical topics are developed in the context of familiar cases, their "fear factor" is reduced. Of course, to keep the examples from becoming overtired, we introduce new case studies throughout the book.
- **Business improvement conclusions that explicitly show how statistical results lead to practical business decisions.** After appropriate analysis and interpretation, examples and case studies often result in a business improvement conclusion. To emphasize this theme of business improvement, icons BI are placed in the page margins to identify when statistical analysis has led to an important business conclusion. The text of each conclusion is also highlighted in yellow for additional clarity.
- **Examples exploited to motivate an intuitive approach to statistical ideas.** Most concepts and formulas, particularly those that introductory students find most challenging, are first approached by working through the ideas in accessible examples. Only after simple and clear analysis within these concrete examples are more general concepts and formulas discussed.
- **A shorter and more intuitive introduction to business statistics in Chapter 1.** Chapter 1 begins with an improved example introducing data and how data can be used to make a successful offer to purchase a house. Random sampling is introducing informally in the context of more tightly focused case studies. [The technical discussion about how to select random samples and other types of samples is in Chapter 7 (Sampling and Sampling Distributions), but the reader has the option of reading about sampling in Chapter 7 immediately after Chapter 1.] Chapter 1 also includes a new discussion of ethical guidelines for practitioners of statistics. Throughout the book, statistics is presented as a broad discipline requiring not simply analytical skills but also judgment and personal ethics.
- **A more streamlined discussion of the graphical and numerical methods of descriptive statistics.** Chapters 2 and 3 utilize several new examples, including an example leading off Chapter 2 that deals with college students' pizza brand preferences. In addition, the explanations of some of the more complicated topics have been simplified. For example, the discussion of percentiles, quartiles, and box plots has been shortened and clarified.
- **An improved, well-motivated discussion of probability and probability distributions in Chapters 4, 5, and 6.** In Chapter 4, methods for calculating probabilities are more clearly motivated in the context of two new examples. We use the Crystal Cable Case, which deals with studying cable television and Internet penetration rates, to illustrate many probabilistic concepts and calculations. Moreover, students' understanding of the important concepts of conditional probability and statistical independence is sharpened by a new real-world case involving gender discrimination at a pharmaceutical company. The probability distribution, mean, and standard deviation of a discrete random variable are all motivated and explained in a more succinct discussion in Chapter 5. An example illustrates how knowledge of a mean and standard deviation are enough to estimate potential investment returns. Chapter 5 also features an improved introduction to the binomial distribution where the previous careful discussion is supplemented by an illustrative tree diagram. Students can now see the origins of all the factors in the binomial formula more clearly. For those students studying the hypergeometric distribution and its relationship to the binomial distribution, a new example is used to show how more simply calculated binomial probabilities can approximate hypergeometric probabilities. Chapter 5 ends with an optional section where joint probabilities and covariances are explained in the context of portfolio diversification. In Chapter 6, continuous probabilities are developed by improved examples. The coffee temperature case introduces the key ideas and is eventually used to help study the normal distribution. Similarly, the elevator waiting time case is used to explore the continuous uniform distribution.

AUTHORS

- **A shorter and clearer discussion of sampling distributions and statistical inference in Chapters 7 through 11.** In Chapter 7, the discussion of sampling distributions is improved by using an example that deals with a small population and then seamlessly proceeding to a related large population example. We have completely rewritten and simplified the introduction to confidence intervals in Chapter 8. The logic and interpretation of a 95% confidence interval is taken up first in the car mileage case. Then we build upon this groundwork to provide students a new graphically based procedure for finding confidence intervals for any level of confidence. We also distinguish between the interpretation of a confidence interval and a tolerance interval. Chapter 8 concludes with an optional section about estimating parameters of finite populations when using either random or stratified random sampling. Hypothesis testing procedures (using both the critical value and *p*-value approaches) are summarized efficiently and visually in new summary boxes in Chapter 9. Students will find these summary boxes much more transparent than traditional summaries lacking visual prompts. These summary boxes are featured throughout the chapters covering inferences for one mean or one proportion (Chapter 9), inferences for two means or two proportions (Chapter 10), and inferences for one or two variances (the new Chapter 11), as well as in later chapters covering regression analysis.
- **Simpler and improved discussions about comparing means, proportions, and variances.** In Chapter 10 we mention the unrealistic "known variance" case only briefly and move swiftly to the more realistic "unknown variance" case. As previously indicated, inference for population variances has been moved to the new Chapter 11. In Chapter 12 (Experimental Design and Analysis of Variance) we have simplified and greatly shortened the discussion of *F*-tests and multiple comparisons for one-way ANOVA, the randomized block design, and the two-way ANOVA. Chapter 13 covers chi-square goodness-of-fit tests and tests of independence.
- **Streamlined and improved discussions of simple and multiple regression, time series forecasting, and statistical quality control.** As in the sixth edition, we use the Tasty Sub Shop Case to introduce the ideas of both simple and multiple regression analysis. This case has been popular with our readers. Regression is now presented in two rather than three chapters. The Durbin-Watson test and transformations of variables are introduced in the simple linear regression chapter (Chapter 14) because they arise naturally in the context of residual analysis. However, both of these topics can be skipped without loss of continuity. After discussing the basics of multiple regression, Chapter 15 has five innovative, advanced sections that can be covered in any order. These optional sections explain (1) using dummy variables, (2) using squared and interaction terms, (3) model building and the effects of multicollinearity, (4) residual analysis in multiple regression (including a short discussion of outlying and influential observations), and (5) logistic regression. The treatment of these topics has been noticeably shortened and improved. Although we include all the regression material found in prior editions of this book, we do so in approximately 40 fewer pages. In Chapter 16 (Time Series Forecasting and Index Numbers), explanations of basic techniques have been simplified and, for advanced readers, an optional new 7-page introduction to Box-Jenkins models has been added. Chapter 17, which deals with process improvement, has been streamlined by relying on a single case, the hole location case, to explain $\bar{X}$ and R charts as well as establishing process control, pattern analysis, and capability studies.
- **Increased emphasis on Excel and MINITAB throughout the text.** The main text features Excel and MINITAB outputs. The end of chapter appendices provide improved step-by-step instructions about how to perform statistical analyses using these software packages as well as MegaStat, an Excel add-in.

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A TOUR OF THIS

Chapter Introductions

Each chapter begins with a list of the section topics that are covered in the chapter, along with chapter learning objectives and a preview of the case study analysis to be carried out in the chapter.

CHAPTER 1

An Introduction to Business Statistics

Learning Objectives

When you have mastered the material in this chapter, you will be able to:

- LO1-1 Define a variable.
- LO1-2 Describe the difference between a quantitative variable and a qualitative variable.
- LO1-3 Describe the difference between cross-sectional data and time series data.
- LO1-4 Construct and interpret a time series (runs) plot.
- LO1-5 Identify the different types of data sources: existing data sources, experimental studies, and observational studies.
- LO1-6 Describe the difference between a population and a sample.
- LO1-7 Distinguish between descriptive statistics and statistical inference.
- LO1-8 Explain the importance of random sampling.
- LO1-9 Identify the ratio, interval, ordinal, and nominative scales of measurement (Optional).

Chapter Outline

- 1.1 Data
- 1.2 Data Sources
- 1.3 Populations and Samples
- 1.4 Three Case Studies That Illustrate Sampling and Statistical Inference
- 1.5 Ratio, Interval, Ordinal, and Nominative Scales of Measurement (Optional)

The subject of **statistics** involves the study of how to collect, analyze, and interpret data. **Data** are facts and figures from which conclusions can be drawn. Such conclusions are important to the decision making of many professions and organizations. For example, **economists** use conclusions drawn from the latest data on unemployment and inflation to help the government make policy decisions. **Financial planners** use recent trends in stock market prices and economic conditions to make investment decisions. **Accountants** use **sample data** concerning a company's *actual sales revenues* to assess whether the company's *claimed sales revenues* are valid. **Marketing professionals** help businesses decide which products to develop and market by using data that reveal consumer preferences. **Production supervisors** use manufacturing data to evaluate, control, and improve product quality. **Politicians** rely on data from public opinion polls to formulate legislation and to devise campaign strategies. **Physicians and hospitals** use data on the effectiveness of drugs and surgical procedures to provide patients with the best possible treatment.

In this chapter we begin to see how we collect and analyze data. As we proceed through the chapter, we introduce several case studies. These case studies (and others to be introduced later) are revisited throughout later chapters as we learn the statistical methods needed to analyze them. Briefly, we will begin to study three cases:

C

The Cell Phone Case. A bank estimates its cellular phone costs and decides whether to outsource management of its wireless resources by studying the calling patterns of its employees.

The Marketing Research Case. A bottling company investigates consumer reaction to a new bottle design for one of its popular soft drinks.

The Car Mileage Case. To determine if it qualifies for a federal tax credit based on fuel economy, an automaker studies the gas mileage of its new midsize model.

1.1 Data

LO1-1 Define a variable.

Data sets, elements, and variables We have said that data are facts and figures from which conclusions can be drawn. Together, the data that are collected for a particular study are referred to as a **data set.** For example, Table 1.1 is a data set that gives information about the new homes sold in a Florida luxury home development over a recent three-month period. Potential buyers in this housing community could choose either the "Diamond" or the "Ruby" home model design and could have the home built on either a lake lot or a treed lot (with no water access).

In order to understand the data in Table 1.1, note that any data set provides information about some group of individual **elements,** which may be people, objects, events, or other entities. The information that a data set provides about its elements usually describes one or more characteristics of these elements.

Any characteristic of an element is called a **variable.**

For the data set in Table 1.1, each sold home is an element, and four variables are used to describe the homes. These variables are (1) the home model design, (2) the type of lot on which the home was built, (3) the list (asking) price, and (4) the (actual) selling price. Moreover, each home model design came with "everything included"—specifically, a complete, luxury interior package and a choice of one of three different architectural exteriors. Therefore, because there were no interior or exterior options to purchase, the (actual) selling price of a home depended solely on the home model design and whatever price reduction (based partially on the lot type) that the community developer (builder) was willing to give.

TABLE 1.1 A Data Set Describing Five Home Sales DS HomeSales

Home	Model Design	Lot Type	List Price	Selling Price
1	Diamond	Lake	$494,000	$494,000
2	Ruby	Treed	$447,000	$398,000
3	Diamond	Treed	$494,000	$440,000
4	Diamond	Treed	$494,000	$469,000
5	Ruby	Lake	$447,000	$447,000

Continuing Case Studies and Business Improvement Conclusions

The main chapter discussions feature real or realistic examples, continuing case studies, and a business improvement theme. The continuing case studies span individual chapters and groups of chapters and tie together different statistical topics. To emphasize the text's theme of business improvement, icons BI are placed in the page margins to identify when statistical analysis has led to an important business improvement conclusion. Each conclusion is also highlighted in yellow for additional clarity. For example, in Chapters 1 and 3 we consider **The Cell Phone Case**:

TABLE 1.4 A Sample of Cellular Usages (in minutes) for 100 Randomly Selected Employees DS CellUse

75	485	37	547	753	93	897	694	797	477
654	578	504	670	490	225	509	247	597	173
496	553	0	198	507	157	672	296	774	479
0	822	705	814	20	513	546	801	721	273
879	433	420	521	648	41	528	359	367	948
511	704	535	585	341	530	216	512	491	0
542	562	49	505	461	496	241	624	885	259
571	338	503	529	737	444	372	555	290	830
719	120	468	730	853	18	479	144	24	513
482	683	212	418	399	376	323	173	669	611

EXAMPLE 3.5 The Cell Phone Case: Reducing Cellular Phone Costs C

Suppose that a cellular management service tells the bank that if its cellular cost per minute for the random sample of 100 bank employees is over 18 cents per minute, the bank will benefit from automated cellular management of its calling plans. Last month's cellular usages for the 100 randomly selected employees are given in Table 1.4 (page 9), and a dot plot of these usages is given in the page margin. If we add together the usages, we find that the 100 employees used a total of 46,625 minutes. Furthermore, the total cellular cost incurred by the 100 employees is found to be $9,317 (this total includes base costs, overage costs, long distance, and roaming). This works out to an average of $9,317/46,625 = $.1998, or 19.98 cents per minute. Because this average cellular cost per minute exceeds 18 cents per minute, the bank will hire the cellular management service to manage its calling plans.

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TEXT'S FEATURES

Figures and Tables

Throughout the text, charts, graphs, tables, and Excel and MINITAB outputs are used to illustrate statistical concepts. For example:

- In Chapter 3 (**Descriptive Statistics: Numerical Methods**), the following figures are used to help explain the **Empirical Rule**. Moreover, in **The Car Mileage Case** an automaker uses the Empirical Rule to find estimates of the "typical," "lowest," and "highest" mileage that a new midsize car should be expected to get in combined city and highway driving. In actual practice, real automakers provide similar information broken down into separate estimates for city and highway driving—see the Buick LaCrosse new car sticker in Figure 3.14.

FIGURE 3.14 The Empirical Rule and Tolerance Intervals for a Normally Distributed Population

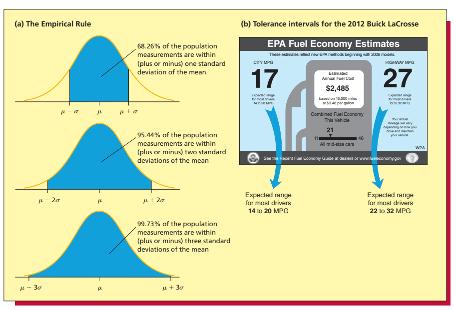
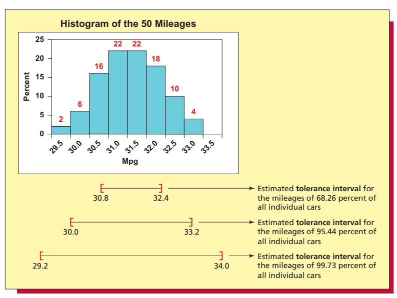


FIGURE 3.15 Estimated Tolerance Intervals in the Car Mileage Case



- In chapter 7 (**Sampling and Sampling Distributions**), the following figures (and others) are used to help explain the **sampling distribution of the sample mean** and the **Central Limit Theorem**. In addition, the figures describe different applications of random sampling in **The Car Mileage Case**, and thus this case is used as an integrative tool to help students understand sampling distributions.

FIGURE 7.1 A Comparison of Individual Car Mileages and Sample Means

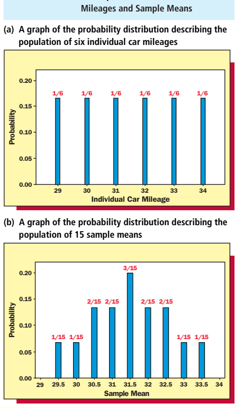


FIGURE 7.2 The Normally Distributed Population of All Individual Car Mileages and the Normally Distributed Population of All Possible Sample Means

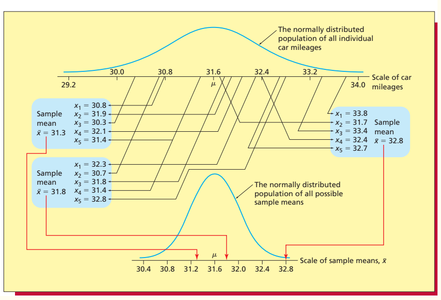


FIGURE 7.3 A Comparison of (1) the Population of All Individual Car Mileages, (2) the Sampling Distribution of the Sample Mean $\bar{x}$ When $n = 5$, and (3) the Sampling Distribution of the Sample Mean $\bar{x}$ When $n = 50$

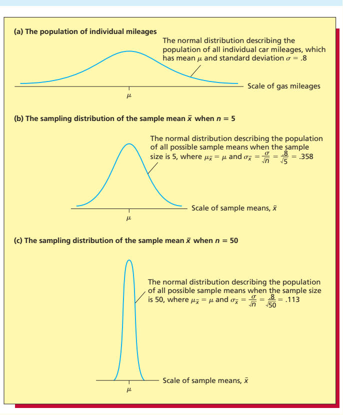
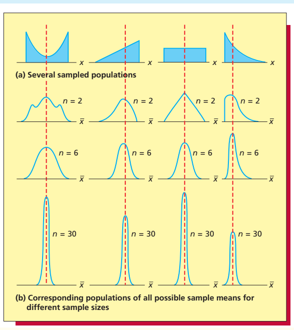


FIGURE 7.5 The Central Limit Theorem Says That the Larger the Sample Size Is, the More Nearly Normally Distributed Is the Population of All Possible Sample Means



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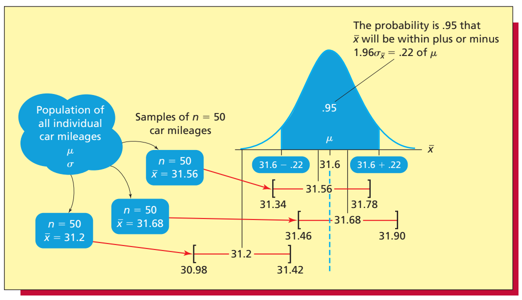
- In Chapter 8 (**Confidence Intervals**), the following figure (and others) are used to help explain the meaning of a **95 percent confidence interval** for the population mean. Furthermore, in **The Car Mileage Case** an automaker uses a confidence interval procedure specified by the Environmental Protection Agency to find the EPA estimate of a new midsize model's true mean mileage.

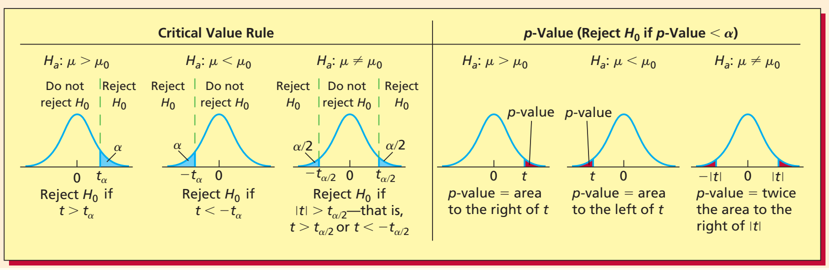
FIGURE 8.2 Three 95 Percent Confidence Intervals for μ



- In Chapter 9 (**Hypothesis Testing**), a five-step hypothesis testing procedure, **new graphical hypothesis testing summary boxes,** and many graphics are used to show how to carry out hypothesis tests.

A t Test about a Population Mean: σ Unknown

Null Hypothesis $H_0: \mu = \mu_0$ **Test Statistic** $t = \dfrac{\bar{x} - \mu_0}{s/\sqrt{n}}$ $df = n - 1$ **Assumptions** Normal population or Large sample size



The Five Steps of Hypothesis Testing

1. State the null hypothesis H_0 and the alternative hypothesis H_a.
2. Specify the level of significance α.
3. Select the test statistic.

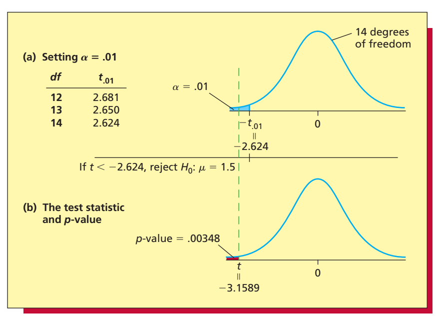
Using a critical value rule:

4. Determine the critical value rule for deciding whether to reject H_0.
5. Collect the sample data, compute the value of the test statistic, and decide whether to reject H_0 by using the critical value rule. Interpret the statistical results.

Using a p-value:

4. Collect the sample data, compute the value of the test statistic, and compute the p-value.
5. Reject H_0 at level of significance α if the p-value is less than α. Interpret the statistical results.

FIGURE 9.5 Testing $H_0: \mu = 1.5$ versus $H_a: \mu < 1.5$ by Using a Critical Value and the p-Value




```
Test of mu = 1.5 vs < 1.5
                                           95% Upper
Variable   N     Mean   StDev  SE Mean       Bound       T      P
Ratio     15   1.3433  0.1921   0.0496      1.4307   -3.16  0.003
```

- In Chapters 14 and 15 (**Simple Linear and Multiple Regression**), a substantial number of data plots, Excel and MINITAB outputs, and other graphics are used to teach simple and multiple regression analysis. For example, in **The Tasty Sub Shop Case** a business entrepreneur uses data plotted in Figures 15.1 and 15.2 and the Excel and MINITAB outputs in Figure 15.4 to predict the yearly revenue of a Tasty Sub Shop restaurant on the basis of the population and business activity near a potential Sub Shop location. Using the **95 percent prediction interval** on the MINITAB output and projected restaurant operating costs, the entrepreneur decides whether to build a Tasty Sub Shop restaurant on the potential site.

TEXT'S FEATURES

FIGURE 15.1 Plot of y (Yearly Revenue) versus x_1 (Population Size)

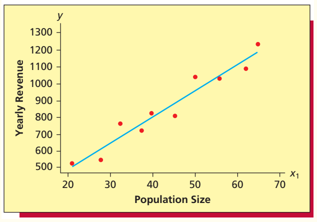


FIGURE 15.2 Plot of y (Yearly Revenue) versus x_2 (Business Rating)

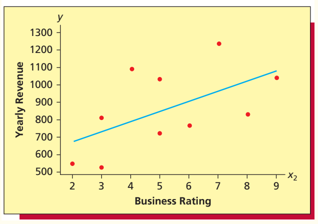


FIGURE 15.4 Excel and MINITAB Outputs of a Regression Analysis of the Tasty Sub Shop Revenue Data in Table 15.1 Using the Model $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$

(a) The Excel output

Regression Statistics	
Multiple R	0.9905
R Square	0.9810 [8]
Adjusted R Square	0.9756 [9]
Standard Error	36.6856 [7]
Observations	10

ANOVA	df	SS	MS	F	Significance F
Regression	2	486355.7 [10]	243177.8	180.689 [13]	9.46E-07 [14]
Residual	7	9420.8 [11]	1345.835		
Total	9	495776.5 [12]			

	Coefficients	Standard Error [4]	t Stat [5]	P-value [6]	Lower 95% [19]	Upper 95% [19]
Intercept	125.289 [1]	40.9333	3.06	0.0183	28.4969	222.0807
population	14.1996 [2]	0.9100	15.60	1.07E-06	12.0478	16.3517
bus_rating	22.8107 [3]	5.7692	3.95	0.0055	9.1686	36.4527

(b) The MINITAB output

```
The regression equation is
revenue = 125 + 14.2 population + 22.8 bus_rating

Predictor         Coef        SE Coef [4]        T [5]       P [6]
Constant        125.29 [1]    40.93             3.06        0.018
population     14.1996 [2]     0.91             15.6        0.000
bus_rating      22.811 [3]    5.769             3.95        0.006
S = 36.6856 [7]        R-Sq = 98.10% [8]        R-Sq(adj) = 97.6% [9]

Analysis of Variance
Source            DF       SS           MS        F            P
Regression         2       486356 [10]  243178    180.69 [13]  0.000 [14]
Residual Error     7       9421 [11]    1346
Total              9       495777 [12]

Predicted Values for New Observations
   New Obs     Fit [15]     SE Fit [16]     95% CI [17]        95% PI [18]
         1     956.6        15              (921.0, 992.2)     (862.8, 1050.4)

Values of Predictors for New Observations
   New Obs     population     bus_rating
         1     47.3           7
```

[1] b_0 [2] b_1 [3] b_2 [4] s_{b_j} = standard error of the estimate b_j [5] t statistics [6] p-values for t statistics [7] s = standard error [8] R^2 [9] Adjusted R^2 [10] Explained variation [11] SSE = Unexplained variation [12] Total variation [13] F(model) statistic [14] p-value for F(model) [15] $\hat{y}$ = point prediction when $x_1 = 47.3$ and $x_2 = 7$ [16] $s_{\hat{y}}$ = standard error of the estimate $\hat{y}$ [17] 95% confidence interval when $x_1 = 47.3$ and $x_2 = 7$ [18] 95% prediction interval when $x_1 = 47.3$ and $x_2 = 7$ [19] 95% confidence interval for β_j

Exercises

Many of the exercises in the text require the analysis of real data. Data sets are identified by an icon in the text and are included on the Online Learning Center (OLC): www.mhhe.com/bowerman7e. Exercises in each section are broken into two parts—"Concepts" and "Methods and Applications"—and there are supplementary and Internet exercises at the end of each chapter.

2.8 Fifty randomly selected adults who follow professional sports were asked to name their favorite professional sports league. The results are as follows where MLB = Major League Baseball, MLS = Major League Soccer, NBA = National Basketball Association, NFL = National Football League, and NHL = National Hockey League. DS ProfSports

NFL	NBA	NFL	MLB	MLB	NHL	NFL	NFL	MLS	MLB
MLB	NFL	MLB	NBA	NBA	NFL	NFL	NFL	NHL	NBA
NBA	NFL	NHL	NFL	MLS	NFL	MLB	NFL	MLB	NFL
NHL	MLB	NHL	NFL	NFL	NFL	MLB	NFL	NBA	NFL
MLS	NFL	MLB	NBA	NFL	NFL	MLB	NBA	NFL	NFL

a Find the frequency distribution, relative frequency distribution, and percent frequency distribution for these data.
b Construct a frequency bar chart for these data.
c Construct a pie chart for these data.
d Which professional sports league is most popular with these 50 adults? Which is least popular?

Chapter Ending Material and Excel/MINITAB/MegaStat® Tutorials

The end-of-chapter material includes a chapter summary, a glossary of terms, important formula references, and comprehensive appendices that show students how to use Excel, MINITAB, and MegaStat.

Chapter Summary

We began this chapter by presenting and comparing several measures of **central tendency.** We defined the **population mean** and we saw how to estimate the population mean by using a **sample mean.** We also defined the **median** and **mode,** and we compared the mean, median, and mode for symmetrical distributions and for distributions that are skewed to the right or left. We then studied measures of **variation** (or *spread*). We defined the **range, variance,** and **standard deviation,** and we saw how to estimate a population variance and standard deviation by using a sample. We learned that a good way to interpret the standard deviation when a population is (approximately) normally distributed is to use the **Empirical Rule,** and we studied **Chebyshev's Theorem,** which gives us intervals containing reasonably large fractions of the population units no matter what the population's shape might be. We also saw that, when a data set is highly skewed, it is best to use **percentiles** and **quartiles** to measure variation, and we learned how to construct a **box-and-whiskers plot** by using the quartiles.

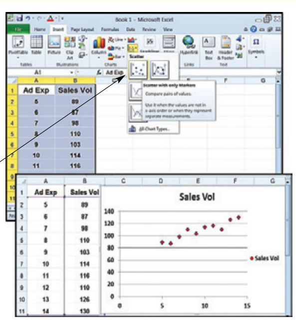
After learning how to measure and depict central tendency and variability, we presented several optional topics. First, we discussed several numerical measures of the relationship between two variables. These included the **covariance,** the **correlation coefficient,** and the **least squares line.** We then introduced the concept of a **weighted mean** and also explained how to compute descriptive statistics for **grouped data.** Finally, we showed how to calculate the **geometric mean** and demonstrated its interpretation.

Glossary of Terms

box-and-whiskers display (box plot): A graphical portrayal of a data set that depicts both the central tendency and variability of the data. It is constructed using Q_1, M_d, and Q_3. (pages 123, 124)
central tendency: A term referring to the middle of a population or sample of measurements. (page 101)
outlier (in a box-and-whiskers display): A measurement less than the lower limit or greater than the upper limit. (page 124)
percentile: The value such that a specified percentage of the measurements in a population or sample fall at or below it. (page 120)
point estimate: A one-number estimate for the value of a population parameter. (page 101)

Constructing a scatter plot of sales volume versus advertising expenditure as in Figure 2.24 on page 67 (data file: SalesPlot.xlsx):

- Enter the advertising and sales data in Table 2.20 on page 67 into columns A and B—advertising expenditures in column A with label "Ad Exp" and sales values in column B with label "Sales Vol." **Note: The variable to be graphed on the horizontal axis must be in the first column** (that is, the left-most column) and **the variable to be graphed on the vertical axis must be in the second column** (that is, the rightmost column).
- Select the entire range of data to be graphed.
- Select **Insert : Scatter : Scatter with only Markers**
- The scatter plot will be displayed in a graphics window. Move the plot to a chart sheet and edit appropriately.



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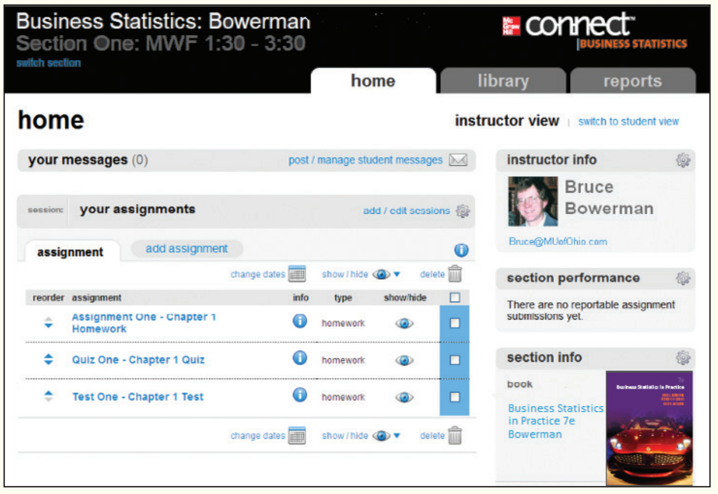

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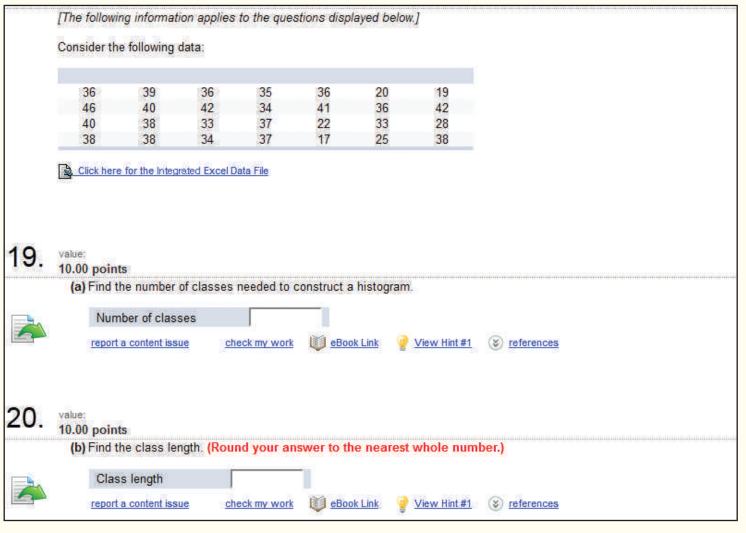

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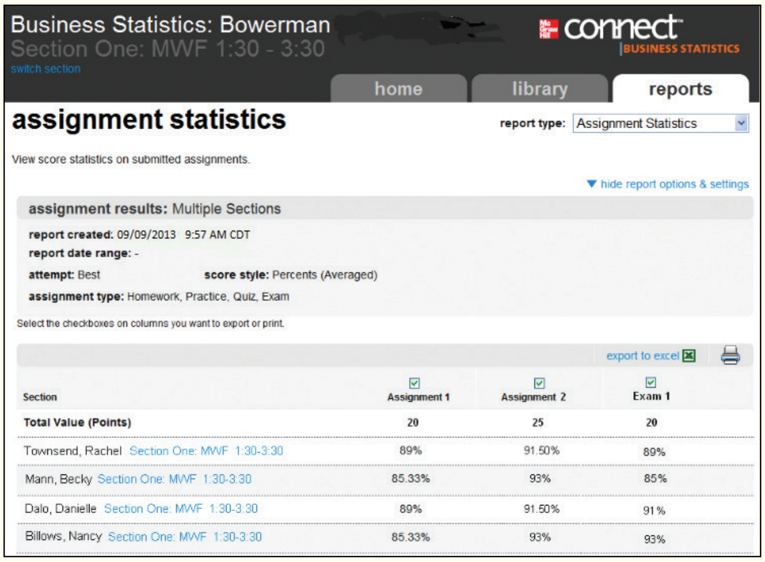

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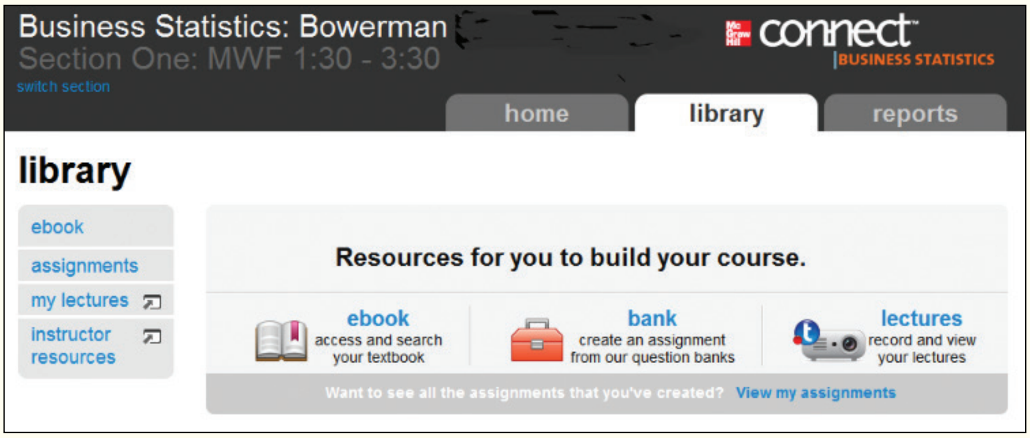

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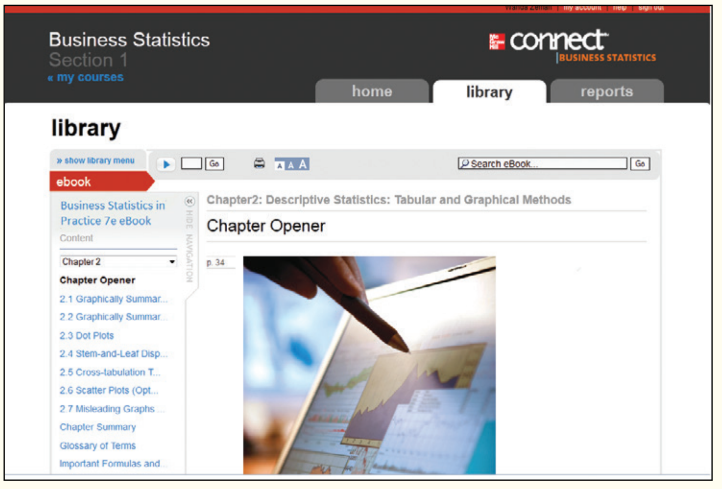

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Access Card ISBN: 0077426274. Note: Best option for both Windows and Mac users. MegaStat is a full-featured Excel add-in by J. B. Orris of Butler University that is available with this text. It performs statistical analyses within an Excel workbook. It does basic functions such as descriptive statistics, frequency distributions, and probability calculations, as well as hypothesis testing, ANOVA, and regression.

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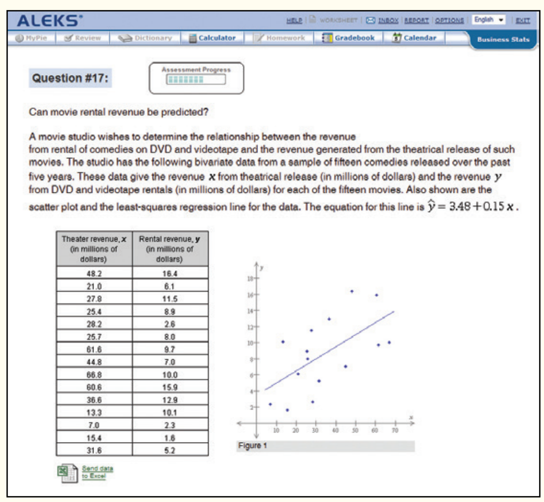

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Chapter-by-Chapter Revisions for 7th Edition

Chapter 1

- Importance of data made clearer in initial example.
- Intuitive explanation of random sampling and introduction of 3 major case studies made more concise.
- New subsection on ethical statistical practice.
- Cable cost example updated.
- Data set for coffee temperature case expanded and ready for use in continuous probability distribution chapter.

Chapter 2

- Pizza preference data replace Jeep preference data in creating bar and pie charts and in business decision making.
- Seven new data sets added.
- Eighteen new exercises replace former exercises.

Chapter 3

- Section on percentages, quartiles, and box plots completely rewritten, simplified, and shortened.
- Ten new data sets used.
- Nineteen new exercises replace former exercises.

Chapter 4

- Main discussion in chapter rewritten and simplified.
- Cable penetration example (based on Time Warner Cable) replaces newspaper subscription example.
- Employment discrimination case (based on real pharmaceutical company) used in conditional probability section.
- Exercises updated in this and all subsequent chapters.

Chapter 5

- Introduction to discrete probability distributions rewritten, simplified, and shortened.
- Binominal distribution introduced using a tree diagram.
- Discussion of hypergeometric distribution improved and slightly expanded.
- Includes new optional section on joint distributions and covariance previously found in an appendix.

Chapter 6

- Introduction to continuous probability distributions improved and motivated by coffee temperature data.
- Uniform distribution section now begins with an example.
- Normal distribution motivated by tie-in to coffee temperature data.

Chapter 7

- A seamless development of the sampling distribution of the sample mean beginning with a small population example and proceeding through the Central Limit Theorem.
- Includes optional section deriving the mean and variance of the sample mean (previously found in an appendix).

Chapter 8

- Introduction to confidence intervals rewritten and simplified.
- Improved graphics help students construct confidence intervals.
- Optional section on parameters of finite populations shortened and simplified; short section on estimation in stratified sampling added.

Chapter 9

- Introduction to z tests streamlined and improved.
- Summary boxes feature innovative graphics to help students test hypotheses using critical values and p-values.

Chapter 10

- Comparison of two population means moves more quickly to the realistic unknown variance case.

Chapter 11

- New chapter covering the chi-square and F distributions and their applications to inferences about one or two population variances.

Chapter 12 (Chapter 11 in the Sixth Edition)

- Discussion of one-way, randomized block, and two-way ANOVA streamlined and simplified.
- Multiple comparisons shortened by emphasizing Tukey procedures.

Chapter 13 (Chapter 12 in the Sixth Edition)

- No significant changes.

Chapter 14 (Chapter 13 in the Sixth Edition)

- Discussion of simple linear regression model and least squares estimation streamlined.
- Durbin-Watson test and model transformations now included in this initial regression chapter.

Chapter 15

- This chapter combines the Sixth Edition's Chapter 14 and Chapter 15. It concludes with 5 innovative and flexible sections which can be covered in any order.

Chapter 16

- Time series regression simplified; new software output is used.
- Exponential smoothing coverage updated and shortened.
- New section on Box-Jenkins models is added.
- Index numbers examples updated.

Chapter 17

- X bar and R charts presented concisely using one example.

Chapter 18

- No significant changes.

Chapter 19

- No significant changes.

Brief Table of Contents

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Experimental Design and Analysis of Variance

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Chapter 16

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Process Improvement Using Control Charts

Chapter 18

Nonparametric Methods

Chapter 19

Decision Theory

Appendix A

DEDICATION

Bruce L. Bowerman
To my wife, children, sister, and other family members:
Drena
Michael, Jinda, Benjamin, and Lex
Asa and Nicole
Susan
Fiona, Radeesa, and Barney
Daphne, Chloe, and Edgar
Gwyneth and Tony
Bobby and Callie
Marmalade, Randy, and Penney
Clarence, Quincy, Teddy, Julius, Charlie, and Sally

Richard T. O'Connell
To my children and grandchild:
Christopher, Bradley, and Sam

Emily S. Murphree
To Kevin and the Math Ladies

Business Statistics in Practice

SEVENTH EDITION

CHAPTER 1

An Introduction to Business Statistics

Learning Objectives

When you have mastered the material in this chapter, you will be able to:

- **LO1-1** Define a variable.
- **LO1-2** Describe the difference between a quantitative variable and a qualitative variable.
- **LO1-3** Describe the difference between cross-sectional data and time series data.
- **LO1-4** Construct and interpret a time series (runs) plot.
- **LO1-5** Identify the different types of data sources: existing data sources, experimental studies, and observational studies.
- **LO1-6** Describe the difference between a population and a sample.
- **LO1-7** Distinguish between descriptive statistics and statistical inference.
- **LO1-8** Explain the importance of random sampling.
- **LO1-9** Identify the ratio, interval, ordinal, and nominative scales of measurement (Optional).

Chapter Outline

The subject of **statistics** involves the study of how to collect, analyze, and interpret data. **Data** are facts and figures from which conclusions can be drawn. Such conclusions are important to the decision making of many professions and organizations. For example, **economists** use conclusions drawn from the latest data on unemployment and inflation to help the government make policy decisions. **Financial planners** use recent trends in stock market prices and economic conditions to make investment decisions. **Accountants** use **sample data** concerning a company's *actual sales revenues* to assess whether the company's *claimed sales revenues* are valid. **Marketing professionals** help businesses decide which products to develop and market by using data that reveal consumer preferences. **Production supervisors** use manufacturing data to evaluate, control, and improve product quality. **Politicians** rely on data from public opinion polls to formulate legislation and to devise campaign strategies. **Physicians and hospitals** use data on the effectiveness of drugs and surgical procedures to provide patients with the best possible treatment.

In this chapter we begin to see how we collect and analyze data. As we proceed through the chapter, we introduce several case studies. These case studies (and others to be introduced later) are revisited throughout later chapters as we learn the statistical methods needed to analyze them. Briefly, we will begin to study three cases:

C

The Cell Phone Case. A bank estimates its cellular phone costs and decides whether to outsource management of its wireless resources by studying the calling patterns of its employees.

The Marketing Research Case. A bottling company investigates consumer reaction to a new bottle design for one of its popular soft drinks.

The Car Mileage Case. To determine if it qualifies for a federal tax credit based on fuel economy, an automaker studies the gas mileage of its new midsize model.

1.1 Data

LO1-1 Define a variable.

Data sets, elements, and variables We have said that data are facts and figures from which conclusions can be drawn. Together, the data that are collected for a particular study are referred to as a **data set.** For example, Table 1.1 is a data set that gives information about the new homes sold in a Florida luxury home development over a recent three-month period. Potential buyers in this housing community could choose either the "Diamond" or the "Ruby" home model design and could have the home built on either a lake lot or a treed lot (with no water access).

In order to understand the data in Table 1.1, note that any data set provides information about some group of individual **elements,** which may be people, objects, events, or other entities. The information that a data set provides about its elements usually describes one or more characteristics of these elements.

Any characteristic of an element is called a **variable.**

For the data set in Table 1.1, each sold home is an element, and four variables are used to describe the homes. These variables are (1) the home model design, (2) the type of lot on which the home was built, (3) the list (asking) price, and (4) the (actual) selling price. Moreover, each home model design came with "everything included"—specifically, a complete, luxury interior package and a choice of one of three different architectural exteriors. Therefore, because there were no interior or exterior options to purchase, the (actual) selling price of a home depended solely on the home model design and whatever price reduction (based partially on the lot type) that the community developer (builder) was willing to give.

TABLE 1.1 A Data Set Describing Five Home Sales DS HomeSales

Home	Model Design	Lot Type	List Price	Selling Price
1	Diamond	Lake	$494,000	$494,000
2	Ruby	Treed	$447,000	$398,000
3	Diamond	Treed	$494,000	$440,000
4	Diamond	Treed	$494,000	$469,000
5	Ruby	Lake	$447,000	$447,000

The data in Table 1.1 are real (with some minor modifications to protect privacy) and were provided by a business executive—a friend of the authors—who recently received a promotion and needed to move to central Florida. While searching for a new home, the executive and his family visited the luxury home community and decided they wanted to purchase a Diamond model on a treed lot. The list price of this home was $494,000, but the developer offered to sell it for an "incentive" price of $469,000. Intuitively, the incentive price's $25,000 savings off list price seemed like a good deal. However, the executive resisted making an immediate decision. Instead, he decided to collect data on the selling prices of new homes recently sold in the community and use the data to assess whether the developer might be amenable to a lower offer. In order to collect "relevant data," the executive talked to local real estate professionals and learned that new homes sold in the community during the previous three months were a good indicator of current home value. Using real estate sales records, the executive also learned that five of the community's new homes had sold in the previous three months. The data given in Table 1.1 are the data that the executive collected about these five homes.

LO1-2 Describe the difference between a quantitative variable and a qualitative variable.

In order to understand the conclusions the business executive reached using the data in Table 1.1, we need to further discuss variables. For any variable describing an element in a data set, we carry out a **measurement** to assign a value of the variable to the element. For example, in the real estate example, real estate sales records gave the actual selling price of each home to the nearest dollar. In another example, a credit card company might measure the time it takes for a cardholder's bill to be paid to the nearest day. Or, in a third example, an automaker might measure the gasoline mileage obtained by a car in city driving to the nearest one-tenth of a mile per gallon by conducting a mileage test on a driving course prescribed by the Environmental Protection Agency (EPA). If the possible measurements of the values of a variable are numbers that represent quantities (that is, "how much" or "how many"), then the variable is said to be **quantitative.** For example, the actual selling price of a home, the payment time of a bill, and the gasoline mileage of a car are all quantitative. However, if we simply record into which of several categories an element falls, then the variable is said to be **qualitative** or **categorical.** Examples of categorical variables include (1) a person's gender, (2) the make of an automobile, (3) whether a person who purchases a product is satisfied with the product, and (4) the type of lot on which a home is built.[1]

Of the four variables in Table 1.1, two variables—list price and selling price—are quantitative, and two variables—model design and lot type—are qualitative. Furthermore, when the business executive examined Table 1.1, he noted that homes on lake lots had sold at their list price, but homes on treed lots had not. Because the executive and his family wished to purchase a Diamond model on a treed lot, the executive also noted that two Diamond models on treed lots had sold in the previous three months. One of these Diamond models had sold for the incentive price of $469,000, but the other had sold for a lower price of $440,000. Hoping to pay the lower price for his family's new home, the executive offered $440,000 for the Diamond model on the treed lot. Initially, the home builder turned down this offer, but two days later the builder called back and accepted the offer. The executive had used data to buy the new home for $54,000 less than the list price and $29,000 less than the incentive price!

LO1-3 Describe the difference between cross-sectional data and time series data.

LO1-4 Construct and interpret a time series (runs) plot.

Cross-sectional and time series data Some statistical techniques are used to analyze *cross-sectional data,* while others are used to analyze *time series data.* **Cross-sectional data** are data collected at the same or approximately the same point in time. For example, suppose that a bank wishes to analyze last month's cell phone bills for its employees. Then, because the cell phone costs given by these bills are for different employees in the same month, the cell phone costs are cross-sectional data. **Time series data** are data collected over different time periods. For example, Table 1.2 presents the average basic cable television rate in the United States for each of the years 1999 to 2009. Figure 1.1 is a **time series plot**—also called a **runs plot**—of these data. Here we plot each television rate on the vertical scale versus its corresponding time index on the horizontal scale. For instance, the first cable rate ($28.92) is plotted versus 1999, the second cable rate ($30.37) is plotted versus 2000, and so forth. Examining the time series plot, we see that the cable rates increased substantially from 1999 to 2009. Finally, because the five homes in Table 1.1 were sold over a three-month period that represented a relatively stable real estate market, we can consider the data in Table 1.1 to essentially be cross-sectional data.

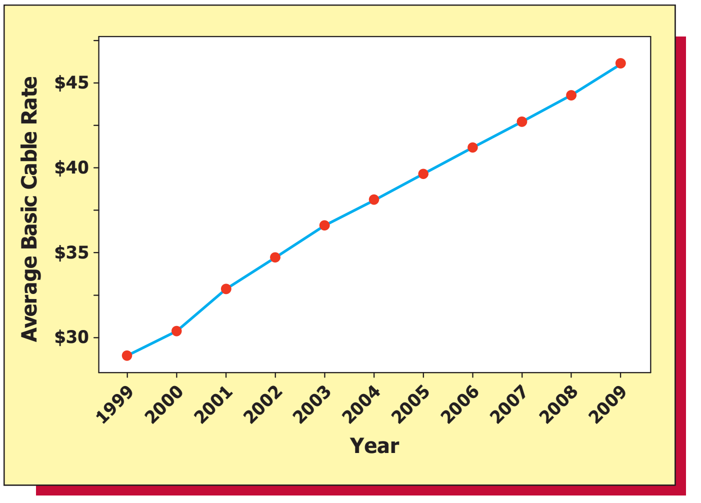
[1]Optional Section 1.5 discusses two types of quantitative variables (ratio and interval) and two types of qualitative variables (ordinal and nominative).

TABLE 1.2 The Average Basic Cable Rates in the U.S. from 1999 to 2009
DS BasicCable

Year	Average Basic Cable Rate
1999	$ 28.92
2000	30.37
2001	32.87
2002	34.71
2003	36.59
2004	38.14
2005	39.63
2006	41.17
2007	42.72
2008	44.28
2009	46.13

Source: U.S. Energy Information Administration, http://www.eia.gov/

FIGURE 1.1 Time Series Plot of the Average Basic Cable Rates in the U.S. from 1999 to 2009
DS BasicCable



1.2 Data Sources

Data can be obtained from *existing sources* or from **experimental and observational studies.**

LO1-5 Identify the different types of data sources: existing data sources, experimental studies, and observational studies.

Existing sources Sometimes we can use data *already gathered* by public or private sources. The Internet is an obvious place to search for electronic versions of government publications, company reports, and business journals, but there is also a wealth of information available in the reference section of a good library or in county courthouse records.

If a business needs information about incomes in the Northeastern states, a natural source is the US Census Bureau's website at http://www.census.gov. By following various links posted on the homepage, you can find income and demographic data for specific regions of the country. Other useful websites for economic and financial data are listed in Table 1.3. All of these are trustworthy sources.

TABLE 1.3 Examples of Public Economic and Financial Data Sites

Title	Website	Data Type
Global Financial Data	https://www.globalfinancialdata.com/index.html	Annual data on stock markets, inflation rates, interest rates, exchange rates, etc.
National Bureau of Economic Research Macrohistory Database	http://www.nber.org/databases/macrohistory/contents/index.html	Historic data on production, construction, employment, money, prices, asset market transactions, foreign trade, and government activity
Federal Reserve Economic Data	http://research.stlouisfed.org/fred2/	Historical U.S. economic and financial data, including daily U.S. interest rates, monetary and business indicators, exchange rate, balance of payments, and regional economic data
Bureau of Labor Statistics	http://stats.bls.gov/	Data concerning employment, inflation, consumer spending, productivity, safety, labor demographics, and the like.
WebEc Economics Data	http://netec.wustl.edu/WebEc/	One of the best complete economics data links including both international and domestic data categorized by area and country
Economic Statistics Briefing Room	http://clinton2.nara.gov/fsbr/esbr.htm	Links to the most current available values of federal economic indicators in 8 categories

Source: Prepared by Lan Ma and Jeffrey S. Simonoff. The authors provide no warranty as to the accuracy of the information provided.

However, given the ease with which anyone can post documents, pictures, weblogs, and videos on the World Wide Web, not all sites are equally reliable. If we were to use a search engine from Google, Netscape, Yahoo, Ask.com, or AltaVista (just to name a few) to find information about the price of a two-bedroom apartment in Manhattan, we would be inundated by millions of "hits." (In fact, a recent search on Google using the keywords "price 2 bedroom apartments Manhattan" yielded 1,040,000 sites.) Some of the sources will be more useful, exhaustive, and error-free than others. Fortunately, the search engines prioritize the lists and provide the most relevant and highly used sites first.

Obviously, performing such web searches costs next to nothing and takes relatively little time, but the tradeoff is that we are also limited in terms of the type of information we are able to find. Another option may be to use a private data source. Most companies keep employee records, for example, and retail establishments retain information about their customers, products, and advertising results. Manufacturing companies may collect information about their processes and defect propagation in order to monitor quality. If we have no affiliation with these companies, however, these data may be more difficult to obtain.

Another alternative would be to contact a data collection agency, which typically incurs some kind of cost. You can either buy subscriptions or purchase individual company financial reports from agencies like Dun & Bradstreet, Bloomberg, Dow Jones & Company, Travel Industry of America, Graduate Management Admission Council, and the Educational Testing Service. If you need to collect specific information, some companies, such as ACNielsen and Information Resources, Inc., can be hired to collect the information for a fee.

Experimental and observational studies There are many instances when the data we need are not readily available from a public or private source. The data might not have been collected at all or they may have been collected in a statistically unsound manner. In cases like these, we need to collect the data ourselves. Suppose we work for a soft drink producer and want to assess consumer reactions to a new bottled water. Since the water has not been marketed yet, we may choose to conduct taste tests, focus groups, or some other market research. Projecting political election results also requires information that is not readily available. In this case, exit polls and telephone surveys are commonly used to obtain the information needed to predict voting trends. New drugs for fighting disease are tested by collecting data under carefully controlled and monitored experimental conditions. In many marketing, political, and medical situations of these sorts, companies hire outside consultants or statisticians to help them obtain appropriate data. Regardless of whether newly minted data are gathered in-house or by paid outsiders, this type of data collection requires much more time, effort, and expense than are needed when data can be found from public or private sources.

When initiating a study, we first define our variable of interest, or **response variable.** Other variables, typically called **factors,** that may be related to the response variable of interest will also be measured. When we are able to set or manipulate the values of these factors, we have an **experimental study.** For example, a pharmaceutical company might wish to determine the most appropriate daily dose of a cholesterol-lowering drug for patients having cholesterol levels over 240 mg/dL, a level associated with a high risk of coronary disease. (http://www.heart.org/HEARTORG/Conditions/Cholesterol/AboutCholesterol/What-Your-Cholesterol-Levels-Mean_UCM_305562_Article.jsp) The company can perform an experiment in which one sample of patients receives a placebo; a second sample receives some low dose; a third a higher dose; and so forth. This is an experiment because the company controls the amount of drug each group receives. The optimal daily dose can be determined by analyzing the patients' responses to the different dosage levels given.

When analysts are unable to control the factors of interest, the study is **observational.** In studies of diet and cholesterol, patients' diets are not under the analyst's control. Patients are often unwilling or unable to follow prescribed diets; doctors might simply ask patients what they eat and then look for associations between the factor *diet* and the response variable *cholesterol.*

Asking people what they eat is an example of performing a **survey.** In general, people in a survey are asked questions about their behaviors, opinions, beliefs, and other characteristics. For instance, shoppers at a mall might be asked to fill out a short questionnaire which seeks their opinions about a new bottled water. In other observational studies, we might simply observe the behavior of people. For example, we might observe the behavior of shoppers as they look at a store display, or we might observe the interactions between students and teachers.

Exercises for Sections 1.1 and 1.2

CONCEPTS

connect

1.1 Define what we mean by a *variable,* and explain the difference between a quantitative variable and a qualitative (categorical) variable.

1.2 Below we list several variables. Which of these variables are quantitative and which are qualitative? Explain.
- **a** The dollar amount on an accounts receivable invoice.
- **b** The net profit for a company in 2009.
- **c** The stock exchange on which a company's stock is traded.
- **d** The national debt of the United States in 2009.
- **e** The advertising medium (radio, television, or print) used to promote a product.

1.3 Discuss the difference between cross-sectional data and time series data. If we record the total number of cars sold in 2011 by each of 10 car salespeople, are the data cross-sectional or time series data? If we record the total number of cars sold by a particular car salesperson in each of the years 2007, 2008, 2009, 2010, and 2011, are the data cross-sectional or time series data?

1.4 Consider a medical study that is being performed to test the effect of smoking on lung cancer. Two groups of subjects are identified; one group has lung cancer and the other one doesn't. Both are asked to fill out a questionnaire containing questions about their age, sex, occupation, and number of cigarettes smoked per day. What is the response variable? Which are the factors? What type of study is this (experimental or observational)?

METHODS AND APPLICATIONS

1.5 Consider the five homes in Table 1.1 (page 3). What do you think you would have to pay for a Ruby model on a treed lot?

1.6 Consider the five homes in Table 1.1 (page 3). What do you think you would have to pay for a Diamond model on a lake lot? For a Ruby model on a lake lot?

1.7 The number of Bismark X-12 electronic calculators sold at Smith's Department Stores over the past 24 months have been: 197, 211, 203, 247, 239, 269, 308, 262, 258, 256, 261, 288, 296, 276, 305, 308, 356, 393, 363, 386, 443, 308, 358, and 384. Make a time series plot of these data. That is, plot 197 versus month 1, 211 versus month 2, and so forth. What does the time series plot tell you? DS CalcSale

1.3 Populations and Samples

LO1-6 Describe the difference between a population and a sample.

We often collect data in order to study a population.

A **population** is the set of all elements about which we wish to draw conclusions.

Examples of populations include (1) all of last year's graduates of Dartmouth College's Master of Business Administration program, (2) all current MasterCard cardholders, and (3) all Buick LaCrosses that have been or will be produced this year.

We usually focus on studying one or more variables describing the population elements. If we carry out a measurement to assign a value of a variable to each and every population element, we have a *population of measurements* (sometimes called *observations*). If the population is small, it is reasonable to do this. For instance, if 150 students graduated last year from the Dartmouth College MBA program, it might be feasible to survey the graduates and to record all of their starting salaries. In general:

If we examine all of the population measurements, we say that we are conducting a **census** of the population.

Often the population that we wish to study is very large, and it is too time-consuming or costly to conduct a census. In such a situation, we select and analyze a subset (or portion) of the population elements.

A **sample** is a subset of the elements of a population.

For example, suppose that 8,742 students graduated last year from a large state university. It would probably be too time-consuming to take a census of the population of all of their starting salaries. Therefore, we would select a sample of graduates, and we would obtain and record their starting salaries. When we measure a characteristic of the elements in a sample, we have a **sample of measurements.**

We often wish to describe a population or sample.

LO1-7 Distinguish between descriptive statistics and statistical inference.

Descriptive statistics is the science of describing the important aspects of a set of measurements.

As an example, if we are studying a set of starting salaries, we might wish to describe (1) how large or small they tend to be, (2) what a typical salary might be, and (3) how much the salaries differ from each other.

When the population of interest is small and we can conduct a census of the population, we will be able to directly describe the important aspects of the population measurements. However, if the population is large and we need to select a sample from it, then we use what we call **statistical inference.**

Statistical inference is the science of using a sample of measurements to make generalizations about the important aspects of a population of measurements.

For instance, we might use a sample of starting salaries to **estimate** the important aspects of a population of starting salaries. In the next section, we begin to look at how statistical inference is carried out.

LO1-8 Explain the importance of random sampling.

1.4 Three Case Studies That Illustrate Sampling and Statistical Inference

Random samples When we select a sample from a population, we hope that the information contained in the sample reflects what is true about the population. One of the best ways to achieve this goal is to select a *random sample.* In Section 7.1 we will precisely define a random sample.[2] For now, it suffices to know that one intuitive way to select a random sample would begin by placing numbered slips of paper representing the population elements in a suitable container. We would thoroughly mix the slips of paper and (blindfolded) choose slips of paper from the container. The numbers on the chosen slips of paper would identify the randomly selected population elements that make up the random sample. In Section 7.1 we will discuss more practical methods for selecting a random sample. We will also see that, although in many situations it is not possible to select a sample that is exactly random, we can sometimes select a sample that is approximately random.

We now introduce three case studies that illustrate the need for a random (or approximately random) sample and the use of such a sample in making statistical inferences. After studying these cases, the reader has the option of studying Section 7.1 (see page 267) and learning practical ways to select random and approximately random samples.

EXAMPLE 1.1 The Cell Phone Case: Reducing Cellular Phone Costs C

Part 1: The cost of company cell phone use Rising cell phone costs have forced companies having large numbers of cellular users to hire services to manage their cellular and other wireless resources. These cellular management services use sophisticated software and mathematical models to choose cost-efficient cell phone plans for their clients. One such firm, mindWireless of Austin, Texas, specializes in automated wireless cost management. According to Kevin Whitehurst, co-founder of mindWireless, cell phone carriers count on *overage*—using more minutes than one's plan allows—and *underage*—using fewer minutes than those already paid for—to deliver almost half of their revenues.[3] As a result, a company's typical cost of cell phone use can be excessive—18 cents per minute or more. However, Mr. Whitehurst explains that by using mindWireless automated cost management to select calling plans, this cost can be reduced to 12 cents per minute or less.

In this case we consider a bank that wishes to decide whether to hire a cellular management service to choose its employees' calling plans. While the bank has over 10,000 employees on

[2]Actually, there are several different kinds of random samples. The type we will define is sometimes called a *simple random sample.* For brevity's sake, however, we will use the term *random sample.*

[3]The authors would like to thank Kevin Whitehurst for help in developing this case.

TABLE 1.4 A Sample of Cellular Usages (in minutes) for 100 Randomly Selected Employees
DS CellUse

75	485	37	547	753	93	897	694	797	477
654	578	504	670	490	225	509	247	597	173
496	553	0	198	507	157	672	296	774	479
0	822	705	814	20	513	546	801	721	273
879	433	420	521	648	41	528	359	367	948
511	704	535	585	341	530	216	512	491	0
542	562	49	505	461	496	241	624	885	259
571	338	503	529	737	444	372	555	290	830
719	120	468	730	853	18	479	144	24	513
482	683	212	418	399	376	323	173	669	611

many different types of calling plans, a cellular management service suggests that by studying the calling patterns of cellular users on 500-minute-per-month plans, the bank can accurately assess whether its cell phone costs can be substantially reduced. The bank has 2,136 employees on a variety of 500-minute-per-month plans with different basic monthly rates, different overage charges, and different additional charges for long distance and roaming. It would be extremely time consuming to analyze in detail the cell phone bills of all 2,136 employees. Therefore, the bank will estimate its cellular costs for the 500-minute plans by analyzing last month's cell phone bills for a *random sample* of 100 employees on these plans.[4]

Part 2: A random sample When the random sample of 100 employees is chosen, the number of cellular minutes used by each sampled employee during last month (the employee's *cellular usage*) is found and recorded. The 100 cellular-usage figures are given in Table 1.4. Looking at this table, we can see that there is substantial overage and underage—many employees used far more than 500 minutes, while many others failed to use all of the 500 minutes allowed by their plan. In Chapter 3 we will use these 100 usage figures to estimate the bank's cellular costs and decide whether the bank should hire a cellular management service.

EXAMPLE 1.2 The Marketing Research Case: Rating a Bottle Design

C

Part 1: Rating a bottle design The design of a package or bottle can have an important effect on a company's bottom line. In this case a brand group wishes to research consumer reaction to a new bottle design for a popular soft drink. To do this, the brand group will show consumers the new bottle and ask them to rate the bottle image. For each consumer interviewed, a bottle image **composite score** will be found by adding the consumer's numerical responses to the five questions shown in Figure 1.2. It follows that the minimum possible bottle image composite

FIGURE 1.2 The Bottle Design Survey Instrument

Please circle the response that most accurately describes whether you agree or disagree with each statement about the bottle you have examined.

Statement	Strongly Disagree						Strongly Agree
The size of this bottle is convenient.	1	2	3	4	5	6	7
The contoured shape of this bottle is easy to handle.	1	2	3	4	5	6	7
The label on this bottle is easy to read.	1	2	3	4	5	6	7
This bottle is easy to open.	1	2	3	4	5	6	7
Based on its overall appeal, I like this bottle design.	1	2	3	4	5	6	7

[4]In Chapter 8 we will discuss how to plan the *sample size*—the number of elements (for example, 100) that should be included in a sample. Throughout this book we will take large enough samples to allow us to make reasonably accurate statistical inferences.