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MARCHAL
WATHEN

SIXTEENTH EDITION

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Statistical Techniques in BUSINESS & ECONOMICS

SIXTEENTH EDITION

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DEDICATION

To Jane, my wife and best friend, and our sons, their wives, and our grandchildren: Mike and Sue (Steve and Courtney), Steve and Kathryn (Kennedy, Jake, and Brady), and Mark and Sarah (Jared, Drew, and Nate).

Douglas A. Lind

To my newest grandchildren (George Orn Marchal, Liam Brophy Horowitz, and Eloise Larae Marchal Murray), newest son-in-law (James Miller Nicholson), and newest wife (Andrea).

William G. Marchal

To my wonderful family: Isaac, Hannah, and Barb.

Samuel A. Wathen

Over the years, we have received many compliments on this text and understand that it's a favorite among students. We accept that as the highest compliment and continue to work very hard to maintain that status.

The objective of *Statistical Techniques in Business and Economics* is to provide students majoring in management, marketing, finance, accounting, economics, and other fields of business administration with an introductory survey of the many applications of descriptive and inferential statistics. We focus on business applications, but we also use many exercises and examples that relate to the current world of the college student. A previous course in statistics is not necessary, and the mathematical requirement is first-year algebra.

In this text, we show beginning students every step needed to be successful in a basic statistics course. This step-by-step approach enhances performance, accelerates preparedness, and significantly improves motivation. Understanding the concepts, seeing and doing plenty of examples and exercises, and comprehending the application of statistical methods in business and economics are the focus of this book.

The first edition of this text was published in 1967. At that time, locating relevant business data was difficult. That has changed! Today, locating data is not a problem. The number of items you purchase at the grocery store is automatically recorded at the checkout counter. Phone companies track the time of our calls, the length of calls, and the identity of the person called. Credit card companies maintain information on the number, time and date, and amount of our purchases. Medical devices automatically monitor our heart rate, blood pressure, and temperature from remote locations. A large amount of business information is recorded and reported almost instantly. CNN, USA Today, and MSNBC, for example, all have websites that track stock prices with a delay of less than 20 minutes.

Today, skills are needed to deal with a large volume of numerical information. First, we need to be critical consumers of information presented by others. Second, we need to be able to reduce large amounts of information into a concise and meaningful form to enable us to make effective interpretations, judgments, and decisions. All students have calculators and most have either personal computers or access to personal computers in a campus lab. Statistical software, such as Microsoft Excel and Minitab, is available on these computers. The commands necessary to achieve the software results are available in Appendix C at the end of the book. We use screen captures within the chapters, so the student becomes familiar with the nature of the software output.

Because of the availability of computers and software, it is no longer necessary to dwell on calculations. We have replaced many of the calculation examples with interpretative ones, to assist the student in understanding and interpreting the statistical results. In addition, we now place more emphasis on the conceptual nature of the statistical topics. While making these changes, we still continue to present, as best we can, the key concepts, along with supporting interesting and relevant examples.

WHAT'S NEW IN THIS SIXTEENTH EDITION?

We have made changes to this edition that we think you and your students will find useful and timely.

- We reorganized the chapters so that each section corresponds to a learning objective. The learning objectives have been revised.
- We expanded the hypothesis testing procedure in Chapter 10 to six steps, emphasizing the interpretation of test results.

- We have revised example/solution sections in various chapters:
  - Chapter 5 now includes a new example/solution used to demonstrate contingency tables and tree diagrams. Also the example/solution demonstrating the combination formula has been revised.
  - Chapter 6 includes a revised example/solution demonstrating the binomial distribution.
  - Chapter 15 includes a new example/solution demonstrating contingency table analysis.
- We have revised the simple regression example in Chapter 13 and increased the number of observations to better illustrate the principles of simple linear regression.
- We have reordered the nonparametric chapters to follow the traditional statistics chapters.
- We moved the sections on one- and two-sample tests of proportions, placing all analysis of nominal data in one chapter: Nonparametric Methods: Nominal Level Hypothesis Tests.
- We combined the answers to the Self-Review Exercises into a new appendix.
- We combined the Software Commands into a new appendix.
- We combined the Glossaries in the section reviews into a single Glossary that follows the appendices at the end of the text.
- We improved graphics throughout the text.

HOW ARE CHAPTERS ORGANIZED TO ENGAGE STUDENTS AND PROMOTE LEARNING?

Chapter Learning Objectives

Each chapter begins with a set of learning objectives designed to provide focus for the chapter and motivate student learning. These objectives, located in the margins next to the topic, indicate what the student should be able to do after completing each section in the chapter.

Chapter Opening Exercise

A representative exercise opens the chapter and shows how the chapter content can be applied to a real-world situation.

MERRILL LYNCH recently completed a study of online investment portfolios for a sample of clients. For the 70 participants in the study, organize these data into a frequency distribution. (See Exercise 43 and LO2-3.)

LEARNING OBJECTIVES

When you have completed this chapter, you will be able to:

- **LO2-1** Summarize qualitative variables with frequency and relative frequency tables.
- **LO2-2** Display a frequency table using a bar or pie chart.
- **LO2-3** Summarize quantitative variables with frequency and relative frequency distributions.
- **LO2-4** Display a frequency distribution using a histogram or frequency polygon.

Introduction to the Topic

Each chapter starts with a review of the important concepts of the previous chapter and provides a link to the material in the current chapter. This step-by-step approach increases comprehension by providing continuity across the concepts.

INTRODUCTION

Chapter 2 began our study of descriptive statistics. To summarize raw data into a meaningful form, we organized qualitative data into a frequency table and portrayed the results in a bar chart. In a similar fashion, we organized quantitative data into a frequency distribution and portrayed the results in a histogram. We also looked at other graphical techniques such as pie charts to portray qualitative data and frequency polygons to portray quantitative data.

This chapter is concerned with two numerical ways of describing quantitative variables, namely, **measures of location** and **measures of dispersion.** Measures of location are often referred to as averages. The purpose of a measure of location is to pinpoint the center of a distribution of data. An

Example/Solution

After important concepts are introduced, a solved example is given. This example provides a how-to illustration and shows a relevant business application that helps students answer the question, "What will I use this for?"

EXAMPLE

The service departments at Tionesta Ford Lincoln Mercury and Sheffield Motors Inc., two of the four Applewood Auto Group dealerships, were both open 24 days last month. Listed below is the number of vehicles serviced last month at the two dealerships. Construct dot plots and report summary statistics to compare the two dealerships.

Tionesta Ford Lincoln Mercury					
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
23	33	27	28	39	26
30	32	28	33	35	32
29	25	36	31	32	27
35	32	35	37	36	30

Self-Reviews

Self-Reviews are interspersed throughout each chapter and closely patterned after the preceding examples. They help students monitor their progress and provide immediate reinforcement for that particular technique.

SELF-REVIEW 4–2

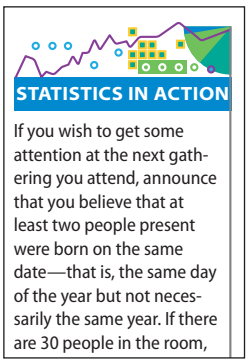
The Quality Control department of Plainsville Peanut Company is responsible for checking the weight of the 8-ounce jar of peanut butter. The weights of a sample of nine jars produced last hour are:

7.69	7.72	7.8	7.86	7.90	7.94	7.97	8.06	8.09

(a) What is the median weight?
(b) Determine the weights corresponding to the first and third quartiles.

Statistics in Action

Statistics in Action articles are scattered throughout the text, usually about two per chapter. They provide unique and interesting applications and historical insights in the field of statistics.



STATISTICS IN ACTION

If you wish to get some attention at the next gathering you attend, announce that you believe that at least two people present were born on the same date—that is, the same day of the year but not necessarily the same year. If there are 30 people in the room,

Definitions

Definitions of new terms or terms unique to the study of statistics are set apart from the text and highlighted for easy reference and review. They also appear in the Glossary at the end of the book.

JOINT PROBABILITY A probability that measures the likelihood two or more events will happen concurrently.

Formulas

Formulas that are used for the first time are boxed and numbered for reference. In addition, a formula card is bound into the back of the text that lists all the key formulas.

SPECIAL RULE OF MULTIPLICATION $P(A \text{ and } B) = P(A)P(B)$ **[5–5]**

Exercises

Exercises are included after sections within the chapter and at the end of the chapter. Section exercises cover the material studied in the section.

EXERCISES

33. $P(A_1) = .60$, $P(A_2) = .40$, $P(B_1|A_1) = .05$, and $P(B_1|A_2) = .10$. Use Bayes' theorem to determine $P(A_1|B_1)$.

34. $P(A_1) = .20$, $P(A_2) = .40$, $P(A_3) = .40$, $P(B_1|A_1) = .25$, $P(B_1|A_2) = .05$, and $P(B_1|A_3) = .10$. Use Bayes' theorem to determine $P(A_3|B_1)$.

35. The Ludlow Wildcats baseball team, a minor league team in the Cleveland Indians organization, plays 70% of their games at night and 30% during the day. The team wins 50% of their night games and 90% of their day games. According to today's newspaper, they won yesterday. What is the probability the game was played at night?

36. Dr. Stallter has been teaching basic statistics for many years. She knows that 80% of the students will complete the assigned problems. She has also determined that among those who do their assignments, 90% will pass the course. Among those students who do not do

Computer Output

The text includes many software examples, using Excel, MegaStat®, and Minitab.

APPLEWOOD AUTO GROUP

	A	B	C	D	E	F	G	H
1	Age	Profit	Location	Vehicle-Type	Previous		*Profit*	
2	21	$1,387	Tionesta	Sedan	0			
3	23	$1,754	Sheffield	SUV	1		Mean	1843.17
4	24	$1,817	Sheffield	Hybrid	1		Standard Error	47.97
5	25	$1,040	Sheffield	Compact	0		Median	1882.50
6	26	$1,273	Kane	Sedan	1		Mode	1915.00
7	27	$1,529	Sheffield	Sedan	1		Standard Deviation	643.63
8	27	$3,082	Kane	Truck	0		Sample Variance	414256.61
9	28	$1,951	Kane	SUV	1		Kurtosis	-0.22
10	28	$2,692	Tionesta	Compact	0		Skewness	-0.24
11	29	$1,342	Kane	Sedan	2		Range	2998
12	29	$1,206	Sheffield	Sedan	0		Minimum	294
13	30	$443	Kane	Sedan	3		Maximum	3292
14	30	$1,621	Sheffield	Truck	1		Sum	331770
15	30	$754	Olean	Sedan	2		Count	180

HOW DOES THIS TEXT REINFORCE STUDENT LEARNING?

BY CHAPTER

Chapter Summary

Each chapter contains a brief summary of the chapter material, including the vocabulary and the critical formulas.

CHAPTER SUMMARY

I. A random variable is a numerical value determined by the outcome of an experiment.
II. A probability distribution is a listing of all possible outcomes of an experiment and the probability associated with each outcome.
  A. A discrete probability distribution can assume only certain values. The main features are:
    1. The sum of the probabilities is 1.00.
    2. The probability of a particular outcome is between 0.00 and 1.00.
    3. The outcomes are mutually exclusive.
  B. A continuous distribution can assume an infinite number of values within a specific range.
III. The mean and variance of a probability distribution are computed as follows.
  A. The mean is equal to:

$$\mu = \Sigma[xP(x)] \qquad [6\text{–}1]$$

  B. The variance is equal to:

$$\sigma^2 = \Sigma[(x - \mu)^2 P(x)] \qquad [6\text{–}2]$$

Pronunciation Key

This tool lists the mathematical symbol, its meaning, and how to pronounce it. We believe this will help the student retain the meaning of the symbol and generally enhance course communications.

PRONUNCIATION KEY

SYMBOL	MEANING	PRONUNCIATION
$P(A)$	Probability of A	*P* of *A*
$P(\sim A)$	Probability of not A	*P* of not *A*
$P(A \text{ and } B)$	Probability of A and B	*P* of *A* and *B*
$P(A \text{ or } B)$	Probability of A or B	*P* of *A* or *B*
$P(A \mid B)$	Probability of A given B has happened	*P* of *A* given *B*
${}_nP_r$	Permutation of n items selected r at a time	*Pnr*
${}_nC_r$	Combination of n items selected r at a time	*Cnr*

Chapter Exercises

Generally, the end-of-chapter exercises are the most challenging and integrate the chapter concepts. The answers and worked-out solutions for all odd-numbered exercises are in Appendix D at the end of the text. Many exercises are noted with a data file icon in the margin. For these exercises, there are data files in Excel format located on the text's website, **www.mhhe.com/lind16e**. These files help students use statistical software to solve the exercises.

CHAPTER EXERCISES

41. The amount of cola in a 12-ounce can is uniformly distributed between 11.96 ounces and 12.05 ounces.
  a. What is the mean amount per can?
  b. What is the standard deviation amount per can?
  c. What is the probability of selecting a can of cola and finding it has less than 12 ounces?
  d. What is the probability of selecting a can of cola and finding it has more than 11.98 ounces?
  e. What is the probability of selecting a can of cola and finding it has more than 11.00 ounces?

42. A tube of Listerine Tartar Control toothpaste contains 4.2 ounces. As people use the toothpaste, the amount remaining in any tube is random. Assume the amount of toothpaste remaining in the tube follows a uniform distribution. From this information, we can determine the following information about the amount remaining in a toothpaste tube without invading anyone's privacy.
  a. How much toothpaste would you expect to be remaining in the tube?
  b. What is the standard deviation of the amount remaining in the tube?
  c. What is the likelihood there is less than 3.0 ounces remaining in the tube?
  d. What is the probability there is more than 1.5 ounces remaining in the tube?

43. Many retail stores offer their own credit cards. At the time of the credit application, the customer is given a 10% discount on the purchase. The time required for the credit application process follows a uniform distribution with the times ranging from 4 minutes to 10 minutes.
  a. What is the mean time for the application process?
  b. What is the standard deviation of the process time?
  c. What is the likelihood a particular application will take less than 6 minutes?

Data Set Exercises

The last several exercises at the end of each chapter are based on three large data sets. These data sets are printed in Appendix A in the text and are also on the text's website. These data sets present the students with real-world and more complex applications.

DATA SET EXERCISES

(The data for these exercises are available at the text website: **www.mhhe.com/lind16e**.)

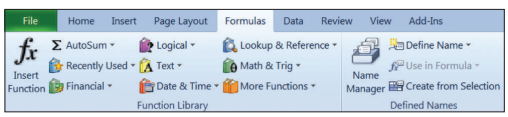
74. Refer to the Real Estate data, which report information on homes sold in the Goodyear, Arizona, area during the last year.
  a. The mean selling price (in $ thousands) of the homes was computed earlier to be $221.10, with a standard deviation of $47.11. Use the normal distribution to estimate the percentage of homes selling for more than $280.0. Compare this to the actual results. Does the normal distribution yield a good approximation of the actual results?
  b. The mean distance from the center of the city is 14.629 miles, with a standard deviation of 4.874 miles. Use the normal distribution to estimate the number of homes 18 or more miles but less than 22 miles from the center of the city. Compare this to the actual results. Does the normal distribution yield a good approximation of the actual results?

Software Commands

Software examples using Excel, MegaStat®, and Minitab are included throughout the text. The explanations of the computer input commands are placed at the end of the text in Appendix C.

CHAPTER 5

5–1. The Excel Commands to determine the number of permutations shown on page 164 are:
  a. Click on the **Formulas** tab in the top menu, then, on the far left, select **Insert Function *fx*.**
  b. In the **Insert Function** box, select **Statistical** as the category, then scroll down to **PERMUT** in the **Select a function list.** Click **OK.**
  c. In the **PERM** box after **Number,** enter *8* and in the **Number_chosen** box enter *3*. The correct answer of *336* appears twice in the box.



Answers to Self-Review

The worked-out solutions to the Self-Reviews are provided at the end of the text in Appendix E.

16–7 a.

		Rank			
x	*y*	*x*	*y*	*d*	d^2
805	23	5.5	1	4.5	20.25
777	62	3.0	9	−6.0	36.00
820	60	8.5	8	0.5	0.25
682	40	1.0	4	−3.0	9.00
777	70	3.0	10	−7.0	49.00
810	28	7.0	2	5.0	25.00
805	30	5.5	3	2.5	6.25
840	42	10.0	5	5.0	25.00
777	55	3.0	7	−4.0	16.00
820	51	8.5	6	2.5	6.25
				0	193.00

BY SECTION

Section Reviews

After selected groups of chapters (1–4, 5–7, 8 and 9, 10–12, 13 and 14, 15 and 16, and 17 and 18), a Section Review is included. Much like a review before an exam, these include a brief **overview** of the chapters and **problems for review.**

A REVIEW OF CHAPTERS 1–4

This section is a review of the major concepts and terms introduced in Chapters 1–4. Chapter 1 began by describing the meaning and purpose of statistics. Next we described the different types of variables and the four levels of measurement. Chapter 2 was concerned with describing a set of observations by organizing it into a frequency distribution and then portraying the frequency distribution as a histogram or a frequency polygon. Chapter 3 began by describing measures of location, such as the mean, weighted mean, median, geometric mean, and mode. This chapter also included measures of dispersion, or spread. Discussed in this section were the range, variance, and standard deviation. Chapter 4 included several graphing techniques such as dot plots, box plots, and scatter diagrams. We also discussed the coefficient of skewness, which reports the lack of symmetry in a set of data.

Cases

The review also includes continuing cases and several small cases that let students make decisions using tools and techniques from a variety of chapters.

CASES

A. Century National Bank

The following case will appear in subsequent review sections. Assume that you work in the Planning Department of the Century National Bank and report to Ms. Lamberg. You will need to do some data analysis and prepare a short written report. Remember, Mr. Selig is the president of the bank, so you will want to ensure that your report is complete and accurate. A copy of the data appears in Appendix A.6.

Century National Bank has offices in several cities in the Midwest and the southeastern part of the United States. Mr. Dan Selig, president and CEO, would like to know the characteristics of his checking account customers. What is the balance of a typical customer?

How many other bank services do the checking account customers use? Do the customers use the ATM service and, if so, how often? What about debit cards? Who uses them, and how often are they used?

balances for the four branches. Is there a difference among the branches? Be sure to explain the difference between the mean and the median in your report.

3. Determine the range and the standard deviation of the checking account balances. What do the first and third quartiles show? Determine the coefficient of skewness and indicate what it shows. Because Mr. Selig does not deal with statistics daily, include a brief description and interpretation of the standard deviation and other measures.

B. Wildcat Plumbing Supply Inc.: Do We Have Gender Differences?

Wildcat Plumbing Supply has served the plumbing needs of Southwest Arizona for more than 40 years. The company was founded by Mr. Terrence St. Julian and is run today by

Practice Test

The Practice Test is intended to give students an idea of content that might appear on a test and how the test might be structured. The Practice Test includes both objective questions and problems covering the material studied in the section.

PRACTICE TEST

There is a practice test at the end of each review section. The tests are in two parts. The first part contains several objective questions, usually in a fill-in-the-blank format. The second part is problems. In most cases, it should take 30 to 45 minutes to complete the test. The problems require a calculator. Check the answers in the Answer Section in the back of the book.

Part 1—Objective

1. The science of collecting, organizing, presenting, analyzing, and interpreting data to assist in making effective decisions is called _____. 1. _____
2. Methods of organizing, summarizing, and presenting data in an informative way are called _____. 2. _____
3. The entire set of individuals or objects of interest or the measurements obtained from all individuals or objects of interest are called the _____. 3. _____
4. List the two types of variables. 4. _____

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- Applies an intelligent concept engine to identify the relationships between concepts and to serve new concepts to each student only when he or she is ready.
- Adapts automatically to each student, so students spend less time on the topics they understand and practice more those they have yet to master.
- Provides continual reinforcement and remediation, but gives only as much guidance as students need.
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- Enables you to assess which concepts students have efficiently learned on their own, thus freeing class time for more applications and discussion.

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Many educational institutions today are focused on the notion of *assurance of learning*, an important element of some accreditation standards. *Statistical Techniques in Business & Economics* is designed specifically to support your assurance of learning initiatives with a simple, yet powerful solution.

Each test bank question for *Statistical Techniques in Business & Economics* maps to a specific chapter learning objective listed in the text. You can use our test bank software, EZ Test and EZ Test Online, or *Connect® Business Statistics* to easily query for learning objectives that directly relate to the learning objectives for your course. You can then use the reporting features of EZ Test to aggregate student results in similar fashion, making the collection and presentation of assurance of learning data simple and easy.

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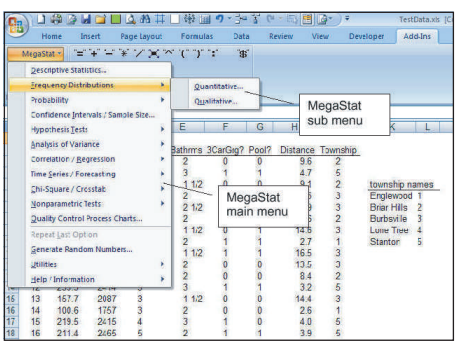
MEGASTAT® FOR MICROSOFT EXCEL®

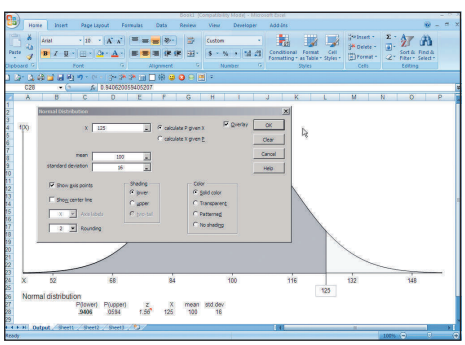
MegaStat® by J. B. Orris of Butler University is a full-featured Excel statistical analysis add-in that is available on the MegaStat website at **www.mhhe.com/megastat** (for purchase). MegaStat works with recent versions of Microsoft Excel® (Windows and Mac OS X). See the website for details on supported versions.

Once installed, MegaStat will always be available on the Excel add-ins ribbon with no expiration date or data limitations. MegaStat performs statistical analyses within an Excel workbook. When a MegaStat menu item is selected, a dialog box pops up for data selection and options. Since MegaStat is an easy-to-use extension of Excel, students can focus on learning statistics without being distracted by the software. Ease-of-use features include Auto Expand for quick data selection and Auto Label detect.

MegaStat does most calculations found in introductory statistics textbooks, such as descriptive statistics, frequency distributions, and probability calculations as well as hypothesis testing, ANOVA chi-square, and regression (simple and multiple). MegaStat output is carefully formatted and appended to an output worksheet.

Video tutorials are included that provide a walkthrough using MegaStat for typical business statistics topics. A context-sensitive help system is built into MegaStat and a User's Guide is included in PDF format.





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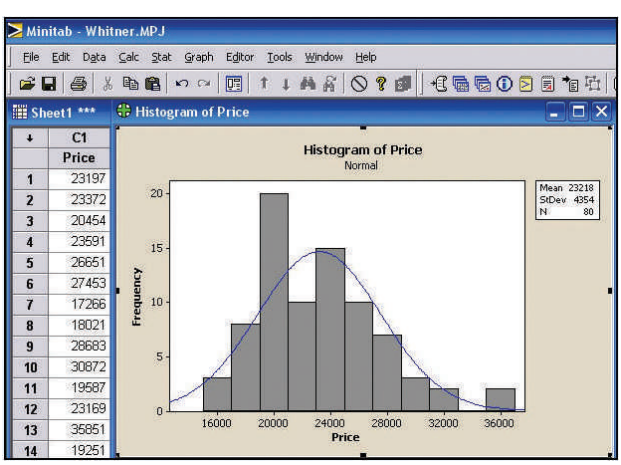

ONLINE LEARNING CENTER:
www.mhhe.com/lind16e

The Online Learning Center (OLC) provides the instructor with a complete Instructor's Manual in Word format, the complete Test Bank in both Word files and computerized EZ Test format, Instructor PowerPoint slides, text art files, an introduction to ALEKS®, an introduction to McGraw-Hill Connect Business Statistics™, and more.

EZ TEST

All test bank questions are available in an EZ Test electronic format. Included are a number of multiple-choice, true/false, and short-answer questions and problems. The answers to all questions are given, along with a rating of the level of difficulty, chapter goal the question tests, Bloom's taxonomy question type, and the AACSB knowledge category.

WebCT/Blackboard/eCollege

All of the material in the Online Learning Center is also available in portable WebCT, Blackboard, or eCollege content "cartridges" provided free to adopters of this text.

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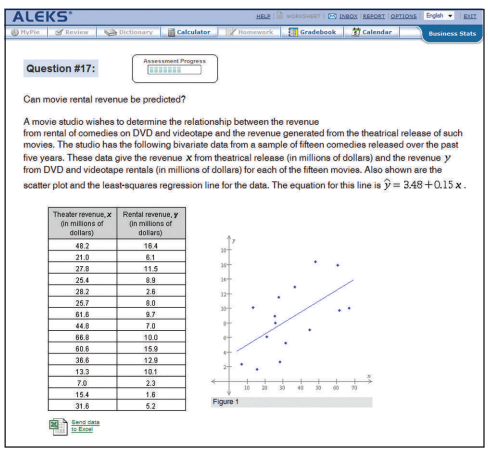
ALEKS is an assessment and learning program that provides individualized instruction in Business Statistics, Business Math, and Accounting. Available online, ALEKS interacts with students much like a skilled human tutor, with the ability to assess precisely a student's knowledge and provide instruction on the exact topics the student is most ready to learn. By providing topics to meet individual students' needs, allowing students to move between explanation and practice, correcting and analyzing errors, and defining terms, ALEKS helps students to master course content quickly and easily.



ALEKS also includes a new instructor module with powerful, assignment-driven features and extensive content flexibility. ALEKS simplifies course management and allows instructors to spend less time with administrative tasks and more time directing student learning. To learn more about ALEKS, visit **www.aleks.com**.

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The Online Learning Center (OLC) provides students with the following content:

- Quizzes
- PowerPoints
- Data sets/files
- Appendixes
- Chapter 20

BUSINESS STATISTICS CENTER (BSC): www.mhhe.com/bstat

The BSC contains links to statistical publications and resources, software downloads, learning aids, statistical websites and databases, and McGraw-Hill product websites and online courses.

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We also wish to thank the staff at McGraw-Hill. This includes Thomas Hayward, Senior Brand Manager; Kaylee Putbrese, Development Editor; Diane Nowaczyk, Content Project Manager; and others we do not know personally, but who have made valuable contributions.

ENHANCEMENTS TO STATISTICAL TECHNIQUES IN BUSINESS & ECONOMICS, 16E

MAJOR CHANGES MADE TO INDIVIDUAL CHAPTERS:

CHAPTER 1 What Is Statistics?

- New photo and chapter opening exercise on the Nook Color sold by Barnes & Noble.
- New introduction with new graphic showing the increasing amount of information collected and processed with new technologies.
- New ordinal scale example based on rankings of states based on business climate.
- The chapter includes several new examples.
- Chapter is more focused on the revised learning objectives and improving the chapter's flow.
- Revised exercise 17 is based on economic data.

CHAPTER 2 Describing Data: Frequency Tables, Frequency Distributions, and Graphic Presentation

- Revised Self-Review 2–3 to include data.
- Updated the company list in revised exercise 38.
- New or revised exercises 45, 47, and 48.

CHAPTER 3 Describing Data: Numerical Measures

- Reorganized chapter based on revised learning objectives.
- Replaced the mean deviation with more emphasis on the variance and standard deviation.
- Updated statistics in action.

CHAPTER 4 Describing Data: Displaying and Exploring Data

- Updated exercise 22 with 2012 New York Yankee player salaries.

CHAPTER 5 A Survey of Probability Concepts

- New explanation of odds compared to probabilities.
- New exercise 21.
- New example/solution for demonstrating contingency tables and tree diagrams.
- New contingency table exercise 31.
- Revised example/solution demonstrating the combination formula.

CHAPTER 6 Discrete Probability Distributions

- Revised the section on the binomial distribution.
- Revised example/solution demonstrating the binomial distribution.
- Revised Self-Review 6–4 applying the binomial distribution.
- New exercise 10 using the number of "underwater" loans.
- New exercise using a raffle at a local golf club to demonstrate probability and expected returns.

CHAPTER 7 Continuous Probability Distributions

- Updated Statistics in Action.
- Revised Self-Review 7–2 based on daily personal water consumption.
- Revised explanation of the Empirical Rule as it relates to the normal distribution.

CHAPTER 8 Sampling Methods and the Central Limit Theorem

- New example of simple random sampling and the application of the table of random numbers.
- The discussions of systematic random, stratified random, and cluster sampling have been revised.
- Revised exercise 44 based on the price of a gallon of milk.

CHAPTER 9 Estimation and Confidence Intervals

- New Statistics in Action describing EPA fuel economy.
- New separate section on point estimates.
- Integration and application of the central limit theorem.
- A revised simulation demonstrating the interpretation of confidence level.
- New presentation on using the *t* table to find *z* values.
- A revised discussion of determining the confidence interval for the population mean.
- Expanded section on calculating sample size.
- New exercise 12 (milk consumption).

CHAPTER 10 One-Sample Tests of Hypothesis

- New example/solution involving airport parking.
- Revised software solution and explanation of *p*-values.
- New exercises 17 (daily water consumption) and 19 (number of text messages by teenagers).
- Conducting a test of hypothesis about a population proportion is moved to Chapter 15.
- New example introducing the concept of hypothesis testing.
- Sixth step added to the hypothesis testing procedure emphasizing the interpretation of the hypothesis test results.

CHAPTER 11 Two-Sample Tests of Hypothesis

- New introduction to the chapter.
- Section of two-sample tests about proportions moved to Chapter 15.

- Changed subscripts in example/solution for easier understanding.
- Updated exercise with 2012 New York Yankee player salaries.

CHAPTER 12 Analysis of Variance

- New introduction to the chapter.
- New exercise 24 using the speed of browsers to search the Internet.
- Revised exercise 33 comparing learning in traditional versus online courses.
- New section on Comparing Two Population Variances.
- New example illustrating the comparison of variances.
- Revised section on two-way ANOVA with interaction with new examples and revised example/solution.
- Revised the names of the airlines in the one-way ANOVA example.
- Changed the subscripts in example/solution for easier understanding.
- New exercise 30 (flight times between Los Angeles and San Francisco).

CHAPTER 13 Correlation and Linear Regression

- Rewrote the introduction section to the chapter.
- The data used as the basis for the North American Copier Sales example/solution used throughout the chapter has been changed and expanded to 15 observations to more clearly demonstrate the chapter's learning objectives.
- Revised section on transforming data using the economic relationship between price and sales.
- New exercises 35 (transforming data), 36 (Masters prizes and scores), 43 (2012 NFL points scored versus points allowed), 44 (store size and sales), and 61 (airline distance and fare).

CHAPTER 14 Multiple Regression Analysis

- Rewrote the section on evaluating the multiple regression equation.
- More emphasis on the regression ANOVA table.
- Enhanced the discussion of the *p*-value in decision making.
- More emphasis on calculating the variance inflation factor to evaluate multicollinearity.

CHAPTER 15 Nonparametric Methods: Nominal Level Hypothesis Tests

- Moved and renamed chapter.
- Moved one-sample and two-sample tests of proportions from Chapters 10 and 11 to Chapter 15.
- New example introducing goodness-of-fit tests.
- Removed the graphical methods to evaluate normality.
- Revised section on contingency table analysis with a new example/solution.
- Revised Data Set exercises.

CHAPTER 16 Nonparametric Methods: Analysis of Ordinal Data

- Moved and renamed chapter.
- New example/solution and self-review demonstrating a hypothesis test about the median.
- New example/solution demonstrating the rank-order correlation.

CHAPTER 17 Index Numbers

- Moved chapter to follow nonparametric statistics.
- Updated dates, illustrations, and examples.
- Revised example/solution demonstrating the use of the Production Price Index to deflate sales dollars.
- Revised example/solution demonstrating the comparison of the Dow Jones Industrial Average and the Nasdaq using indexing.
- New self-review about using indexes to compare two different measures over time.
- Revised Data Set Exercise.

CHAPTER 18 Time Series and Forecasting

- Moved chapter to follow nonparametric statistics and index numbers.
- Updated dates, illustrations, and examples.
- Revised section on the components of a time series.
- Revised graphics for better illustration.

CHAPTER 19 Statistical Process Control and Quality Management

- Updated 2012 Malcolm Baldrige National Quality Award winners.

BRIEF CONTENTS

CONTENTS

What Is Statistics?

1

BARNES & NOBLE recently began selling an electronic book reader called the Nook Color. With this device, you can download from a selection of over two million e-books, newspapers, and magazines. It displays downloaded materials in full color. Assume you know the number of Nook Color units sold each day for the last month at the Barnes & Noble store at the Market Commons Mall in Riverside, California. Describe a condition in which this information could be considered a sample. Illustrate a second situation in which the same data would be regarded as a population. (See Exercise 11 and LO1-3.)

LEARNING OBJECTIVES

When you have completed this chapter, you will be able to:

- **LO1-1** Explain why knowledge of statistics is important.
- **LO1-2** Define statistics and provide an example of how statistics is applied.
- **LO1-3** Differentiate between descriptive and inferential statistics.
- **LO1-4** Classify variables as qualitative or quantitative, and discrete or continuous.
- **LO1-5** Distinguish between nominal, ordinal, interval, and ratio levels of measurement.
- **LO1-6** List the values associated with the practice of statistics.

INTRODUCTION

Suppose you work for a large company and your supervisor asks you to decide if a new version of a smartphone should be produced and sold. You start by thinking about the product's innovations and new features. Then, you stop and realize the weight of the decision. The product will need to make a profit so the pricing and the costs of production and distribution are all very important. The decision to introduce the product is based on many alternatives. So how will you know? Where do you start?

Without a long experience in the industry, beginning to develop an intelligence that will make you an expert is essential. You select three other people to work with and meet with them. The conversation focuses on what you need to know and what information and data you need. In your meeting, many questions are asked. How many competitors are already in the market? How are smartphones priced? What design features do competitors' products have? What features does the market require? What do customers want in a smartphone? What do customers like about the existing products? The answers will be based on business intelligence consisting of data and information collected through customer surveys, engineering analysis, and market research. In the end, your presentation to support your decision regarding the introduction of a new smartphone is based on the statistics that you use to summarize and organize your data, the statistics that you use to compare the new product to existing products, and the statistics to estimate future sales, costs, and revenues. The statistics will be the focus of the conversation that you will have with your supervisor about this very important decision.

As a decision maker, you will need to acquire and analyze data to support your decisions. The purpose of this text is to develop your knowledge of basic statistical techniques and methods and how to apply them to develop the business and personal intelligence that will help you make decisions.

LO1-1
Explain why knowledge of statistics is important.

WHY STUDY STATISTICS?

If you look through your university catalogue, you will find that statistics is required for many college programs. As you investigate a future career in accounting, economics, human resources, finance, or other business area, you will also discover that statistics is required as part of these college programs. So why is an education in statistics a requirement in so many disciplines?

A major driver of the requirement for statistics knowledge is the technologies available for capturing data. Examples include the technology that Google uses to track how Internet users access websites. As people use Google to search the Internet, Google records every search and then uses these data to sort and prioritize the results for future Internet searches. One recent estimate indicates that Google processes 20,000 terabytes of information per day. Big-box retailers like Target, Walmart, Kroger, and others scan every purchase and use the data to manage the distribution of products, to make decisions about marketing and sales, and to track daily and even hourly sales. Police departments collect and use data to provide city residents with maps that communicate information about crimes committed and their location. Every organization is collecting and using data to develop knowledge and intelligence that will help people make informed decisions, and to track the implementation of their decisions. The graphic to the left shows the amount of data generated every minute (**www.domo.com**). A good working knowledge of statistics is useful for summarizing and organizing data to provide information that is useful and supportive of decision making. Statistics is used to make valid comparisons and to predict the outcomes of decisions.

In summary, there are at least three reasons for studying statistics: (1) data are collected everywhere and require statistical knowledge to

make the information useful, (2) statistical techniques are used to make professional and personal decisions, and (3) no matter what your career, you will need a knowledge of statistics to understand the world and to be conversant in your career. An understanding of statistics and statistical method will help you make more effective personal and professional decisions.

LO1-2
Define statistics and provide an example of how statistics is applied.

WHAT IS MEANT BY STATISTICS?

This question can be rephrased in two, subtly different ways: what are statistics and what is statistics? To answer the first question, a statistic is a number used to communicate a piece of information. Examples of **statistics** are:

- The inflation rate is 2%.
- Your grade point average is 3.5.
- The price of a new Tesla premium electric sedan is $85,400.

Each of these statistics is a numerical fact and communicates a very limited piece of information that is not very useful by itself. However, if we recognize that each of these statistics is part of a larger discussion, then the question "what **is** statistics" is applicable. Statistics is the set of knowledge and skills used to organize, summarize, and analyze data. The results of statistical analysis will start interesting conversations in the search for knowledge and intelligence that will help us make decisions. For example:

- The inflation rate for the calendar year was 2%. By applying statistics we could compare this year's inflation rate to the past observations of inflation. Is it higher, lower, or about the same? Is there a trend of increasing or decreasing inflation? Is there a relationship between interest rates and government bonds?
- Your grade point average (GPA) is 3.5. By collecting data and applying statistics, you can determine the required GPA to be admitted to the Master of Business Administration program at the University of Chicago, Harvard, or the University of Michigan. You can determine the likelihood that you would be admitted to a particular program. You may be interested in interviewing for a management position with Procter & Gamble. What GPA does Procter & Gamble require for college graduates with a bachelor's degree? Is there a range of acceptable GPAs?
- You are budgeting for a new car. You would like to own an electric car with a small carbon footprint. The price for the Tesla premium electric sedan is $85,400. By collecting additional data and applying statistics, you can analyze the alternatives. For example, another choice is a hybrid car that runs on both gas and electricity such as a Toyota Prius. It can be purchased for about $27,000. Another hybrid, the Chevrolet Volt, costs about $32,000. What are the differences in the cars' specifications? What additional information can be collected and summarized so that you can make a good purchase decision?

Another example of using statistics to provide information to evaluate decisions is the distribution and market share of Frito-Lay products. Data are collected on each of the Frito-Lay product lines. These data include the market share and the pounds of product sold. Statistics is used to present this information in a bar chart in Chart 1–1. It clearly shows Frito-Lay's dominance in the potato, corn, and tortilla chip markets. It also shows the absolute measure of pounds of each product line consumed in the United States.

These examples show that statistics is more than the presentation of numerical information. Statistics is about collecting and processing information to create a conversation, to stimulate additional questions, and to provide a basis for making decisions. Specifically, we define statistics as:

STATISTICS The science of collecting, organizing, presenting, analyzing, and interpreting data to assist in making more effective decisions.

STATISTICS IN ACTION

We call your attention to a feature of our textbook—*Statistics in Action*. Read each one carefully to get an appreciation of the wide application of statistics in management, economics, nursing, law enforcement, sports, and other disciplines.

- In 2013, *Forbes* published a list of the richest Americans. William Gates, founder of Microsoft Corporation, is the richest. His net worth is estimated at $66.0 billion. (**www.forbes.com**)
- In 2013, the four largest privately owned American companies, ranked by revenue, were Cargill, Koch Industries, Mars, and Bechtel. (**www.forbes.com**)
- In the United States, a typical high school graduate earns $652 per week, a typical college graduate with a bachelor's degree earns $1,066 per week, and a typical college graduate with a master's degree earns $1,300 per week. (**www.bls.gov/emp/ep_chart_001.htm**)

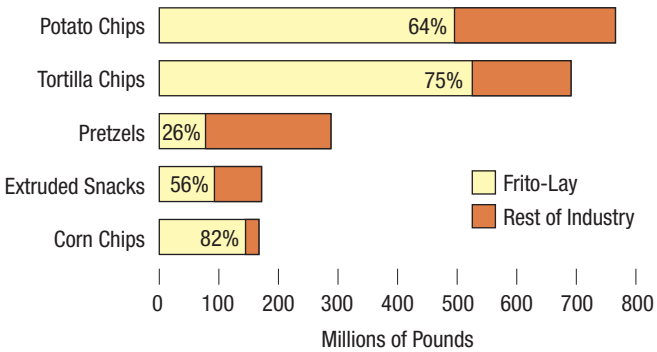


CHART 1–1 Frito-Lay Volume and Share of Major Snack Chip Categories in U.S. Supermarkets

In this book, you will learn the basic techniques and applications of statistics that you can use to support your decisions, both personal and professional. To start, we will differentiate between descriptive and inferential statistics.

LO1-3
Differentiate between descriptive and inferential statistics.

TYPES OF STATISTICS

When we use statistics to generate information for decision making from data, we use either descriptive statistics or inferential statistics. Their application depends on the questions asked and the type of data available.

Descriptive Statistics

Masses of unorganized data—such as the census of population, the weekly earnings of thousands of computer programmers, and the individual responses of 2,000 registered voters regarding their choice for president of the United States—are of little value as is. However, descriptive statistics can be used to organize data into a meaningful form. We define **descriptive statistics** as:

DESCRIPTIVE STATISTICS Methods of organizing, summarizing, and presenting data in an informative way.

The following are examples that apply descriptive statistics to summarize a large amount of data and provide information that is easy to understand.

- There are a total of 46,837 miles of interstate highways in the United States. The interstate system represents only 1% of the nation's total roads but carries more than 20% of the traffic. The longest is I-90, which stretches from Boston to Seattle, a distance of 3,099 miles. The shortest is I-878 in New York City, which is 0.70 mile in length. Alaska does not have any interstate highways, Texas has the most interstate miles at 3,232, and New York has the most interstate routes with 28.
- The average person spent $103.00 on traditional Valentine's Day merchandise in 2013. This is an increase of $0.50 from 2012. As in previous years, men spent nearly twice the amount women spent on the holiday. The average man spent $135.35 to impress the people in his life while women only spent $72.28. Family pets also feel the love; the average person spent $3.27 on his or her furry friends, up from $2.17 last year.

Statistical methods and techniques to generate descriptive statistics are presented in Chapters 2 and 4. These include organizing and summarizing data with frequency distributions and presenting frequency distributions with charts and graphs.

In addition, statistical measures to summarize the characteristics of a distribution are discussed in Chapter 3.

Inferential Statistics

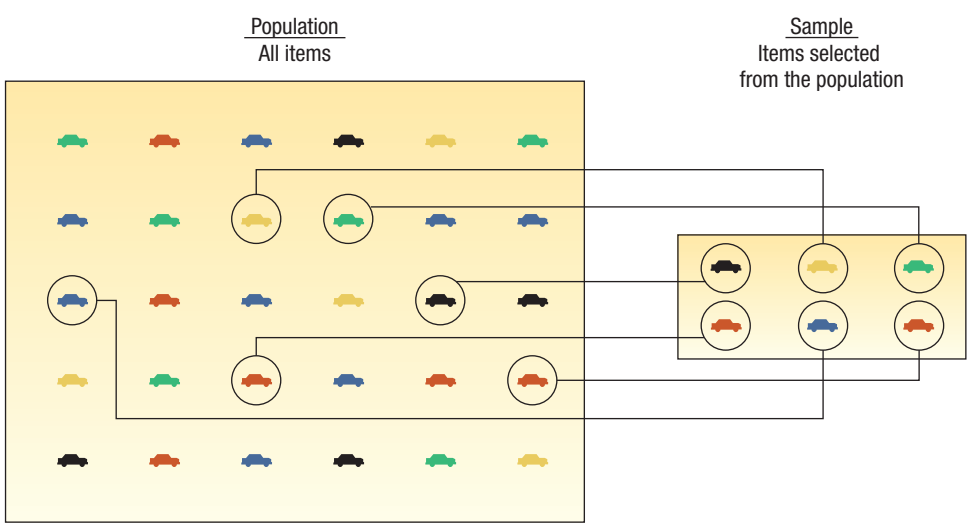
Sometimes we must make decisions based on a limited set of data. For example, we would like to know the operating characteristics, such as fuel efficiency measured by miles per gallon, of sport utility vehicles (SUVs) currently in use. If we spent a lot of time, money, and effort, all the owners of SUVs could be surveyed. In this case, our goal would be to survey the **population** of SUV owners.

POPULATION The entire set of individuals or objects of interest or the measurements obtained from all individuals or objects of interest.

However, based on inferential statistics, we can survey a limited number of SUV owners and collect a **sample** from the population.

SAMPLE A portion, or part, of the population of interest.

Samples are often used to obtain reliable estimates of population parameters. (Sampling is discussed in Chapter 8). In the process, we make trade-offs between the time, money, and effort to collect the data and the error of estimating a population parameter. The process of sampling SUVs is illustrated in the following graphic. In this example, we would like to know the mean or average SUV fuel efficiency. To estimate the mean of the population, six SUVs are sampled and the mean of their MPG is calculated.



So, the sample of six SUVs represents evidence from the population that we use to reach an inference or conclusion about the average MPG for all SUVs. The process of sampling from a population with the objective of estimating properties of a population is called **inferential statistics.**

INFERENTIAL STATISTICS The methods used to estimate a property of a population on the basis of a sample.

Inferential statistics is widely applied to learn something about a population in business, agriculture, politics, and government, as shown in the following examples:

- Television networks constantly monitor the popularity of their programs by hiring Nielsen and other organizations to sample the preferences of TV viewers. For example, 10.5% of a sample of households with TVs watched *The Big Bang Theory* during the week of February 25, 2012 (**www.nielsen.com**). These program ratings are used to make decisions about advertising rates and whether to continue or cancel a program.
- In 2012, a sample of 40 U.S. Internal Revenue Service volunteer program sites was selected and the volunteer tax preparers were tested with three standard tax returns. The sample indicated that tax returns were completed with a 49% accuracy rate. In this example, the statistics are used to make decisions about how to improve the accuracy rate by correcting the most common errors and improving the training of volunteers. (**www.treasury.gov/tigta/auditreports/2012reports/201240088fr.pdf**)

A feature of our text is self-review problems. There are a number of them interspersed throughout each chapter. The first self-review follows. Each self-review tests your comprehension of preceding material. The answer and method of solution are given in Appendix E. You can find the answer to the following self-review in 1–1 in Appendix E. We recommend that you solve each one and then check your answer.

SELF-REVIEW 1–1

The answers are in Appendix E.

The Atlanta-based advertising firm Brandon and Associates asked a sample of 1,960 consumers to try a newly developed chicken dinner by Boston Market. Of the 1,960 sampled, 1,176 said they would purchase the dinner if it is marketed.

(a) What could Brandon and Associates report to Boston Market regarding acceptance of the chicken dinner in the population?

(b) Is this an example of descriptive statistics or inferential statistics? Explain.

LO1-4 Classify variables as qualitative or quantitative, and discrete or continuous.

TYPES OF VARIABLES

There are two basic types of variables: (1) qualitative and (2) quantitative (see Chart 1–2). When an object or individual is observed and recorded as a nonnumeric characteristic, it is a qualitative variable or an attribute. Examples of qualitative variables are gender, beverage preference, type of vehicle owned, state of birth, and eye color. When a variable is qualitative, we usually count the number of observations for each category and determine

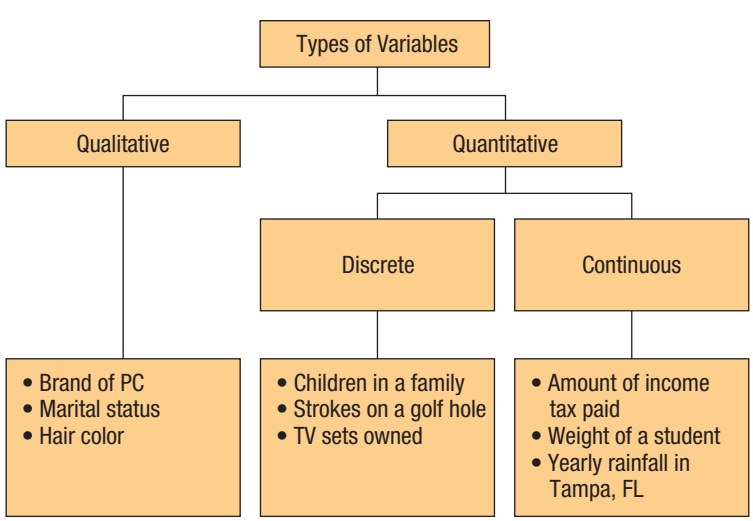


CHART 1–2 Summary of the Types of Variables

what percent are in each category. For example, if we observe the variable eye color, what percent of the population has blue eyes and what percent has brown eyes? If the variable is type of vehicle, what percent of the total number of cars sold last month were SUVs? Qualitative variables are often summarized in charts and bar graphs (Chapter 2).

When a variable can be reported numerically, the variable is called a quantitative variable. Examples of quantitative variables are the balance in your checking account, the ages of company presidents, the life of a car battery (such as 42 months), and the number of people employed by a company.

Quantitative variables are either discrete or continuous. Discrete variables can assume only certain values, and there are "gaps" between the values. Examples of discrete variables are the number of bedrooms in a house (1, 2, 3, 4, etc.), the number of cars arriving at Exit 25 on I-4 in Florida near Walt Disney World in an hour (326, 421, etc.), and the number of students in each section of a statistics course (25 in section A, 42 in section B, and 18 in section C). We count, for example, the number of cars arriving at Exit 25 on I-4, and we count the number of statistics students in each section. Notice that a home can have 3 or 4 bedrooms, but it cannot have 3.56 bedrooms. Thus, there is a "gap" between possible values. Typically, discrete variables are counted.

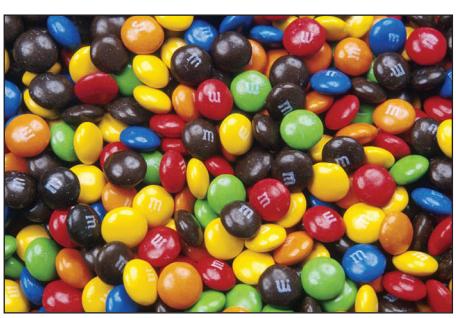
Observations of a continuous variable can assume any value within a specific range. Examples of continuous variables are the air pressure in a tire and the weight of a shipment of tomatoes. Other examples are the ounces of raisins in a box of raisin bran cereal and the duration of flights from Orlando to San Diego. Grade point average (GPA) is a continuous variable. We could report the GPA of a particular student as 3.2576952. The usual practice is to round to 3 places—3.258. Typically, continuous variables result from measuring.

LO1-5

Distinguish between nominal, ordinal, interval, and ratio levels of measurement.

LEVELS OF MEASUREMENT

Data can be classified according to levels of measurement. The level of measurement determines how data should be summarized and presented. It will also indicate the type of statistical analysis that can be performed. Here are two examples of the relationship between measurement and how we apply statistics. There are six colors of candies in a bag of M&Ms. Suppose we assign brown a value of 1, yellow 2, blue 3, orange 4, green 5, and red 6. What kind of variable is the color of an M&M? It is a qualitative variable. Suppose someone summarizes M&M color by adding the assigned color values, divides the sum by the number of M&Ms, and reports that the mean color is 3.56. How do we interpret this statistic? You are correct in concluding that it has no meaning as a measure of M&M color. As a qualitative variable, we can only report the count and percentage of each color in a bag of M&Ms. As a second example, in a high school track meet there are eight competitors in the 400-meter run. We report the order of finish and that the mean finish is 4.5. What does the mean finish tell us? Nothing! In both of these instances, we have not used the appropriate statistics for the level of measurement.



There are four levels of measurement: nominal, ordinal, interval, and ratio. The lowest, or the most primitive, measurement is the nominal level. The highest is the ratio level of measurement.

Nominal-Level Data

For the **nominal level of measurement,** observations of a qualitative variable are measured and recorded as labels or names. The labels or names can only be classified and counted. There is no particular order to the labels.

NOMINAL LEVEL OF MEASUREMENT Data recorded at the nominal level of measurement is represented as labels or names. They have no order. They can only be classified and counted.

STATISTICS IN ACTION

Where did statistics get its start? In 1662 John Graunt published an article called "Natural and Political Observations Made upon Bills of Mortality." The author's "observations" were the result of a study and analysis of a weekly church publication called "Bill of Mortality," which listed births, christenings, and deaths and their causes. Graunt realized that the Bills of Mortality represented only a fraction of all births and deaths in London. However, he used the data to reach broad conclusions about the impact of disease, such as the plague, on the general population. His logic is an example of statistical inference. His analysis and interpretation of the data are thought to mark the start of statistics.

The classification of the six colors of M&M milk chocolate candies is an example of the nominal level of measurement. We simply classify the candies by color. There is no natural order. That is, we could report the brown candies first, the orange first, or any of the other colors first. Recording the variable gender is another example of the nominal level of measurement. Suppose we count the number of students entering a football game with a student ID and report how many are men and how many are women. We could report either the men or the women first. For the data measured at the nominal level, we are limited to counting the number in each category of the variable. Often, we convert these counts to percentages. For example, a study of the color of M&M candies reports the following results (**www.sensationalcolor.com/color-trends/most-popular-colors-177/mam-colors.html**):

Color	Percent in a bag
Blue	24%
Green	20
Orange	16
Yellow	14
Red	13
Brown	13

To process the data for a variable measured at the nominal level, we often numerically code the labels or names. For example, if we are interested in measuring the home state for students at East Carolina University, we would assign a student's home state of Alabama a code of 1, Alaska a code of 2, Arizona a 3, and so on. Using this procedure with an alphabetical listing of states, Wisconsin is coded 49 and Wyoming 50. Realize that the number assigned to each state is still a label or name. The reason we assign numerical codes is to facilitate counting the number of students from each state with statistical software. Note that assigning numbers to the states does not give us license to manipulate the codes as numerical information. Specifically, in this example, $1 + 2 = 3$ corresponds to Alabama + Alaska = Arizona. Clearly, the nominal level of measurement does not permit any mathematical operation that has any valid interpretation.

Ordinal-Level Data

The next higher level of measurement is the **ordinal level.** For this level of measurement a qualitative variable or attribute is either ranked or rated on a relative scale.

ORDINAL LEVEL OF MEASUREMENT Data recorded at the ordinal level of measurement is based on a relative ranking or rating of items based on a defined attribute or qualitative variable. Variables based on this level of measurement are only ranked or counted.

Best Business Climate

1. Texas
2. Utah
3. Virginia
4. Florida
5. Louisiana
6. Indiana
7. South Carolina
8. Tennessee
9. Georgia
10. Nebraska

For example, many businesses make decisions about where to locate their facilities; in other words, where is the best place for their business? Business Facilities (**www.businessfacilities.com**) publishes a list of the top 10 states for the "best business climate." The 2012 rankings are shown to the left. They are based on the evaluation of 20 different factors, including the cost of labor, business tax climate, quality of life, transportation infrastructure, educated workforce, and economic growth potential to rank states based on the attribute "best business climate."

This is an example of an ordinal scale because the states are ranked in order of best to worst business climate. That is, we know the relative order of the states

based on the attribute. For example, in 2012 Texas had the best business climate. Louisiana was fifth, and that was better than South Carolina but not as good as Virginia. Notice that we cannot say that Texas's business climate is five times better than Louisiana's business climate because the magnitude of the differences between the states is not known.

Another example of the ordinal level measure is based on a scale that measures an attribute. This type of scale is used when students rate instructors on a variety of attributes. One attribute may be: "Overall, how do you rate the quality of instruction in this class?" A student's response is recorded on a relative scale of inferior, poor, good, excellent, and superior. An important characteristic of using a relative measurement scale is that we cannot distinguish the magnitude of the differences between groups. We do not know if the difference between "Superior" and "Good" is the same as the difference between "Poor" and "Inferior."

Table 1–1 lists the frequencies of student ratings of instructional quality for Professor James Brunner in an Introduction to Finance course. The data are summarized based on the order of the scale used to rate the instructor. That is, they are summarized by the number of students who indicated a rating of superior (6), good (28), and so on. We can also convert the frequencies to percentages. About 37.8% of the students rated the instructor as good.

TABLE 1–1 Rating of a Finance Professor

Rating	Frequency
Superior	6
Good	28
Average	25
Poor	12
Inferior	3

Interval-Level Data

The **interval level of measurement** is the next highest level. It includes all the characteristics of the ordinal level, but, in addition, the difference or interval between values is meaningful.

INTERVAL LEVEL OF MEASUREMENT For data recorded at the interval level of measurement, the interval or the distance between values is meaningful. The interval level of measurement is based on a scale with a known unit of measurement.

The Fahrenheit temperature scale is an example of the interval level of measurement. Suppose the high temperatures on three consecutive winter days in Boston are 28, 31, and 20 degrees Fahrenheit. These temperatures can be easily ranked, but we can also determine the interval or distance between temperatures. This is possible because 1 degree Fahrenheit represents a constant unit of measurement. That is, the distance between 10 and 15 degrees Fahrenheit is 5 degrees, and is the same as the 5-degree distance between 50 and 55 degrees Fahrenheit. It is also important to note that 0 is just a point on the scale. It does not represent the absence of the condition. The measurement of zero degrees Fahrenheit does not represent the absence of heat or cold. But by our own measurement scale, it is cold! A major limitation of a variable measured at the interval level is that we cannot make statements similar to 20 degrees Fahrenheit is twice as warm as 10 degrees Fahrenheit.