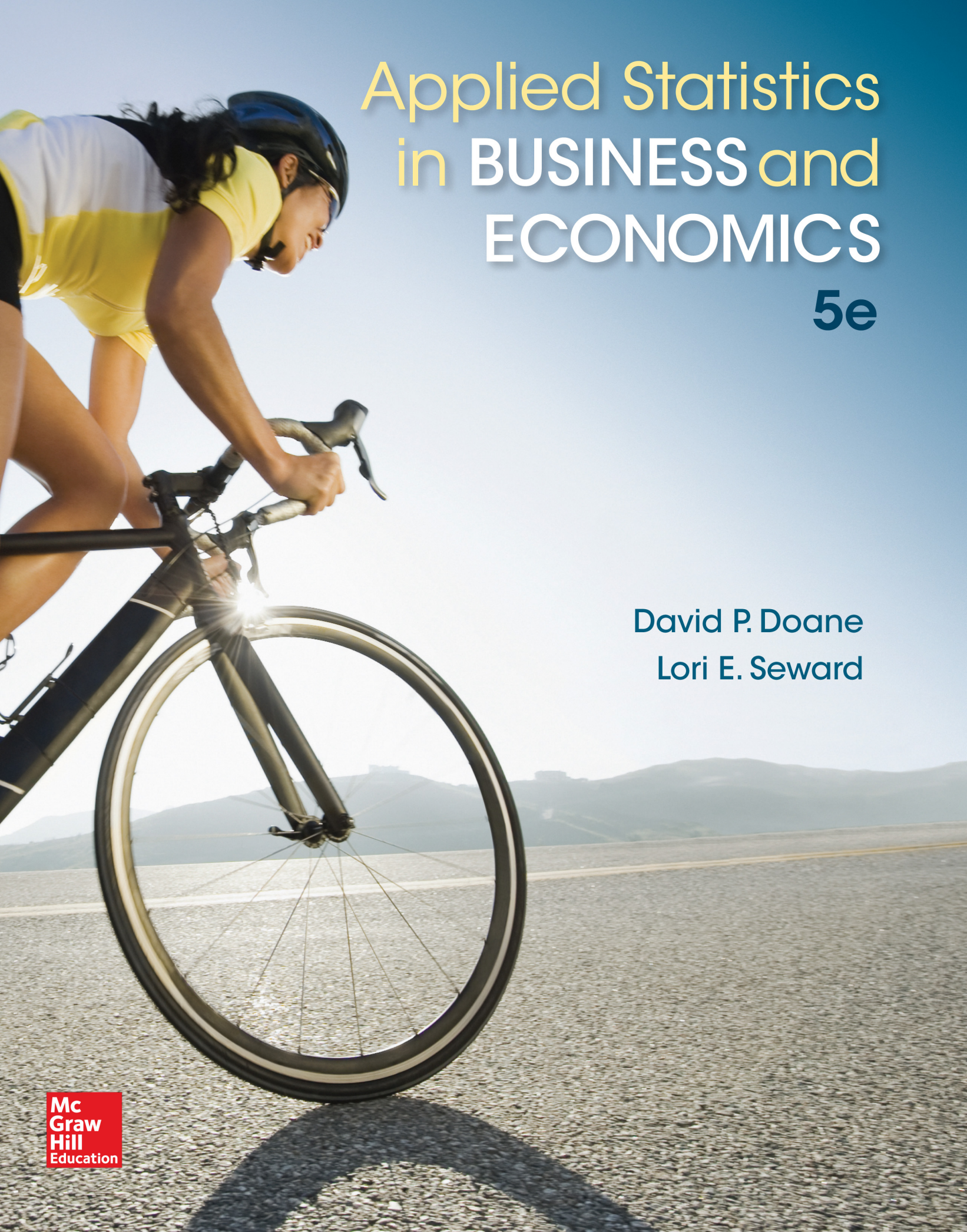

Applied Statistics in BUSINESS and ECONOMICS

5e

David P. Doane
Lori E. Seward

Mc Graw Hill Education

Applied Statistics

in Business and Economics

Fifth Edition

Applied Statistics

in Business and Economics

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APPLIED STATISTICS IN BUSINESS AND ECONOMICS, FIFTH EDITION

This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 0 DOW/DOW 1 0 9 8 7 6 5

ISBN 978-0-07-783730-3
MHID 0-07-783730-4

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Library of Congress Cataloging-in-Publication Data

Doane, David P.
Applied statistics in business and economics / David P. Doane, Lori E. Seward. — Fifth edition.
pages cm
ISBN 978-0-07-783730-3 (alk. paper)
1. Commercial statistics. 2. Management—Statistical methods. 3. Economics—Statistical methods.
4. Statistics. I. Seward, Lori Welte, 1962- II. Title.
HF1017.D55 2016
519.5—dc23

2014044939

www.mhhe.com

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Lori E. Seward is a senior instructor of Operations Management in The Leeds School of Business at the University of Colorado in Boulder. She earned her Bachelor of Science and Master of Science degrees in Industrial Engineering at Virginia Tech. After several years working as a reliability and quality engineer in the paper and automotive industries, she earned her PhD from Virginia Tech and joined the faculty at The Leeds School in 1998. She has been the coordinator of the undergraduate core business statistics course and currently teaches the core MBA statistics course. She is also responsible for coordinating the undergraduate program in Operations Management. She served as the chair of the INFORMS Teachers' Workshop for the annual 2004 meeting. Her teaching interests focus on developing pedagogy that uses technology to create a collaborative learning environment in large undergraduate and MBA statistics courses. Her most recent article, co-authored with David Doane, was published in the *Journal of Statistics Education* (2011).

DEDICATION

To Robert Hamilton Doane-Solomon

David

To all my students who challenged me to make statistics relevant to their lives.

Lori

FROM THE

> "How often have you heard people/students say about a particular subject, 'I'll never use this in the real world'? I thought statistics was a bit on the 'math-geeky' side at first. Imagine my horror when I saw α, R^2, and correlations on several financial reports at my current job (an intern position at a financial services company). I realized then that I had better try to understand some of this stuff."
>
> —*Jill Odette (an introductory statistics student)*

As recently as a decade ago our students used to ask us, "**How** do I use statistics?" Today we more often hear, "**Why** should I use statistics?" *Applied Statistics in Business and Economics* has attempted to provide real meaning to the use of statistics in our world by using real business situations and real data and appealing to your need to know *why* rather than just *how*.

With over 50 years of teaching statistics between the two of us, we feel we have something to offer. Seeing how students have changed as the new century unfolds has required us to adapt and seek out better ways of instruction. So we wrote *Applied Statistics in Business and Economics* to meet four distinct objectives.

Objective 1: Communicate the Meaning of Variation in a Business Context Variation exists everywhere in the world around us. Successful businesses know how to measure variation. They also know how to tell when variation should be responded to and when it should be left alone. We'll show how businesses do this.

Objective 2: Use Real Data and Real Business Applications Examples, case studies, and problems are taken from published research or real applications whenever possible. Hypothetical data are used when it seems the best way to illustrate a concept. You can usually tell the difference by examining the footnotes citing the source.

Objective 3: Incorporate Current Statistical Practices and Offer Practical Advice With the increased reliance on computers, statistics practitioners have changed the way they use statistical tools. We'll show the current practices and explain why they are used the way they are. We will also tell you when each technique should *not* be used.

Objective 4: Provide More In-Depth Explanation of the Why and Let the Software Take Care of the How It is critical to understand the importance of communicating with data. Today's computer capabilities make it much easier to summarize and display data than ever before. We demonstrate easily mastered software techniques using the common software available. We also spend a great deal of time on the idea that there are risks in decision making and those risks should be quantified and directly considered in every business decision.

Our experience tells us that students want to be given credit for the experience they bring to the college classroom. We have tried to honor this by choosing examples and exercises set in situations that will draw on students' already vast knowledge of the world and knowledge gained from other classes. Emphasis is on thinking about data, choosing appropriate analytic tools, using computers effectively, and recognizing limitations of statistics.

What's New in This Fifth Edition?

In this fifth edition we have listened to you and have made many changes that you asked for. We sought advice from students and faculty who are currently using the textbook, reviewers at a variety of colleges and universities, and participants in focus groups on teaching statistics with technology. At the end of this preface is a detailed list of chapter-by-chapter improvements, but here are just a few of them:

- Step-by-step instructions and new screen shots on using Excel 2013 for descriptive statistics, histograms, scatter plots, line charts, and pivot tables.
- Updated exercises with emphasis on compatibility with Connect.
- Updated test bank questions matched with topics and learning objectives.
- Addition of topics requested by reviewers, including more on logistic regression.
- Rewritten instructor's manual with step-by-step solutions.
- New and updated Mini Cases for economics and business.
- Improved explanations of data types, random sampling, probability, and distributions.
- Streamlined sections on Types I and II error, hypothesis formulation, and decision rules.
- More focus on one-factor ANOVA and interpreting ANOVA results.

- Clarification of Wilcoxon rank sum test (Mann–Whitney test) with illustration of two versions.
- End of each chapter guides to downloads from Connect® (simulations, demonstrations, tips, and video tutorials for Excel, *MegaStat,* and MINITAB).

Software

Excel is used throughout this book because it is available everywhere. Some calculations are illustrated using *MegaStat*, an Excel add-in whose Excel-based menus and spreadsheet format offer more capability than Excel's Data Analysis Tools. MINITAB menus and examples are also included to point out similarities and differences of these tools. To assist students who need extra help or "catch up" work, the text website contains tutorials or demonstrations on using Excel, MINITAB, or *MegaStat* for the tasks of each chapter. At the end of each chapter is a list of *LearningStats* demonstrations that illustrate the concepts from the chapter. These demonstrations can be found in the Connect product for this text.

Math Level

The assumed level of mathematics is pre-calculus, though there are rare references to calculus where it might help the better-trained reader. All but the simplest proofs and derivations are omitted, though key assumptions are stated clearly. The learner is advised what to do when these assumptions are not fulfilled. Worked examples are included for basic calculations, but the textbook does assume that computers will do the calculations after the statistics class is over, so, *interpretation* is paramount. End-of-chapter references and suggested websites are given so that interested readers can deepen their understanding.

Exercises

Simple practice exercises are placed within each section. End-of-chapter exercises tend to be more integrative or to be embedded in more realistic contexts. Attention has been given to revising exercises so that they have clear-cut answers that are matched to specific learning objectives. A few exercises invite short answers rather than just quoting a formula. Answers to most odd-numbered exercises are in the back of the book (all of the answers are in the instructor's manual).

LearningStats

Connect users can access *LearningStats,* a collection of Excel spreadsheets, Word documents, and PowerPoints for each chapter. It is intended to let students explore data and concepts at their own pace, ignoring material they already know and focusing on things that interest them. *LearningStats* includes explanations on topics that are not covered in other software packages, such as how to write effective reports, how to perform calculations, or how to make effective charts. It also includes topics that did not appear prominently in the textbook (e.g., partial *F*-test, Durbin–Watson test, sign test, bootstrap simulation, and logistic regression). Instructors can use *LearningStats* PowerPoint presentations in the classroom, but Connect users can also use them for self-instruction. No instructor can "cover everything," but students can be encouraged to explore *LearningStats* data sets and/or demonstrations perhaps with an instructor's guidance.

David P. Doane
Lori E. Seward

HOW ARE CHAPTERS ORGANIZED

Chapter Contents

Each chapter begins with a short list of section topics that are covered in the chapter.

Chapter Learning Objectives

Each chapter includes a list of learning objectives students should be able to attain upon reading and studying the chapter material. Learning objectives give students an overview of what is expected and identify the goals for learning. Learning objectives also appear next to chapter topics in the margins.

CHAPTER CONTENTS

CHAPTER LEARNING OBJECTIVES

LO When you finish this chapter you should be able to

LO 1-1 Define statistics and explain some of its uses.
LO 1-2 List reasons for a business student to study statistics.
LO 1-3 Explain the uses of statistics in business.
LO 1-4 State the common challenges facing business professionals using statistics.
LO 1-5 List and explain common statistical pitfalls.

Section Exercises

Multiple section exercises are found throughout the chapter so that students can focus on material just learned.

SECTION EXERCISES

connect

4.12 (a) For each data set, find the median, midrange, and geometric mean. (b) Are they reasonable measures of central tendency? Explain.

a. Exam scores (9 students) 42, 55, 65, 67, 68, 75, 76, 78, 94
b. GPAs (8 students) 2.25, 2.55, 2.95, 3.02, 3.04, 3.37, 3.51, 3.66
c. Class absences (12 students) 0, 0, 0, 0, 0, 1, 2, 3, 3, 5, 5, 15

4.13 (a) Write the Excel function for the 10 percent trimmed mean of a data set in cells A1:A50. (b) How many observations would be trimmed in each tail? (c) How many would be trimmed overall?

4.14 In the Excel function =TRIMMEAN(Data,.10), how many observations would be trimmed from each end of the sorted data array named Data if (a) $n = 41$, (b) $n = 66$, and (c) $n = 83$?

4.15 The city of Sonando Hills has 8 police officers. In January, the work-related medical expenses for each officer were 0, 0, 0, 0, 0, 0, 150, 650. (a) Calculate the mean, median, mode, midrange, and geometric mean. (b) Which measure of center would you use to budget the expected medical expenses for the whole year by all officers?

Mini Cases

Every chapter includes two or three mini cases, which are solved applications. They show and illlustrate the analytical application of specific statistical concepts at a deeper level than the examples.

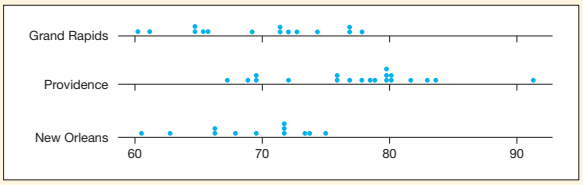
Mini Case 4.2

Prices of Lipitor®

Prescription drug prices vary across the United States and even among pharmacies in the same city. A consumer research group examined prices for a 30-day supply of Lipitor® (a cholesterol-lowering prescription drug) in three U.S. cities at various pharmacies. Attention has recently been focused on prices of such drugs because recent medical research has suggested more aggressive treatment of high cholesterol levels in patients at risk for heart disease. This poses an economic issue for government because Medicare is expected to pay some of the cost of prescription drugs. It is also an issue for Pfizer, the maker of Lipitor®, who expects a fair return on its investments in research and patents. Finally, it is an issue for consumers who seek to shop wisely.

From the dot plots in Figure 4.17, we gain an impression of the *variability* of the data (the *range* of prices for each drug) as well as the *center* of the data (the middle or typical data values). Lipitor® prices vary from about $60 to about $91 and typically are in the $70s. The dot plots suggest that Providence tends to have higher prices, and New Orleans lower prices, though there is considerable variation among pharmacies.

FIGURE 4.17 Dot Plots for Lipitor® Prices



TO PROMOTE STUDENT LEARNING?

Figures and Tables

Throughout the text, there are hundreds of charts, graphs, tables, and spreadsheets to illustrate statistical concepts being applied. These visuals help stimulate student interest and clarify the text explanations.

FIGURE 4.19

Center versus Variability

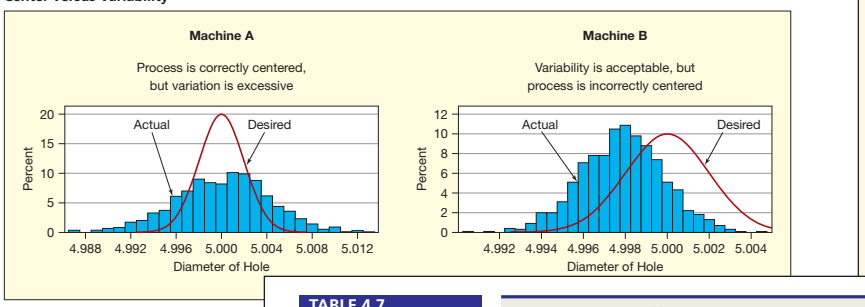


TABLE 4.7

JetBlue Airlines Revenue (millions of dollars) JetBlue

Year	Revenue
2006	2,361
2007	2,843
2008	3,392
2009	3,292
2010	3,779

Source: http://money.msn.com. Data are for December 31 of each year.

Examples

Examples of interest to students are taken from published research or real applications to illustrate the statistics concept. For the most part, examples are focused on business, but there are also some that are more general and don't require any prerequisite knowledge. And there are some that are based on student projects.

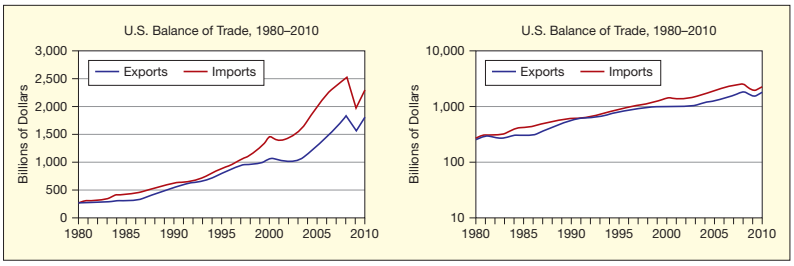
EXAMPLE 3.2

U.S. Trade USTrade

Figure 3.15 shows the U.S. balance of trade. The arithmetic scale shows that growth has been exponential. Yet, although exports and imports are increasing in absolute terms, the log graph suggests that the *growth rate* in both series may be slowing because the log graph is slightly concave. On the log graph, the recently increasing trade deficit is not *relatively* as large. Regardless how it is displayed, the trade deficit remains a concern for policymakers, for fear that foreigners may no longer wish to purchase U.S. debt instruments to finance the trade deficit.

FIGURE 3.15

Comparison of Arithmetic and Log Scales USTrade



Source: *Economic Report of the President, 2011*, Table B24.

Data Set Icon

A data set icon is used throughout the text to identify data sets used in the figures, examples, and exercises that are included in Connect for the text.

USTrade

HOW DOES THIS TEXT REINFORCE

Chapter Summary

Chapter summaries provide an overview of the material covered in the chapter.

CHAPTER SUMMARY

For a set of observations on a single numerical variable, a **stem-and-leaf plot** or a **dot plot** displays the individual data values, while a **frequency distribution** classifies the data into classes called **bins** for a **histogram** of **frequencies** for each bin. The number of bins and their limits are matters left to your judgment, though **Sturges' Rule** offers advice on the number of bins. The **line chart** shows values of one or more **time series** variables plotted against time. A **log scale** is sometimes used in time series charts when data vary by orders of magnitude. The **bar chart** or **column chart** shows a **numerical** data value for each category of an **attribute.** However, a bar chart can also be used for a time series. A **scatter plot** can reveal the association (or lack of association) between two variables X and Y. The **pie chart** (showing a **numerical** data value for each category of an **attribute** if the data values are parts of a whole) is common but should be used with caution. Sometimes a **simple table** is the best visual display. Creating effective visual displays is an acquired skill. Excel offers a wide range of charts from which to choose. Deceptive graphs are found frequently in both media and business presentations, and the consumer should be aware of common errors.

Key Terms

Key terms are highlighted and defined within the text. They are also listed at the ends of chapters to aid in reviewing.

KEY TERMS

Center	*Variability*	*Shape*	*Other*
geometric mean	Chebyshev's Theorem	bimodal distribution	box plot
mean	coefficient of variation	kurtosis	covariance
median	Empirical Rule	leptokurtic	five-number summary
midhinge	mean absolute deviation	mesokurtic	interquartile range
midrange	outliers	multimodal distribution	method of medians
mode	population variance	negatively skewed	quartiles
trimmed mean	range	platykurtic	sample correlation coefficient
weighted mean	sample variance	positively skewed	
		skewed left	

Commonly Used Formulas

Some chapters provide a listing of commonly used formulas for the topic under discussion.

Commonly Used Formulas in Descriptive Statistics

Sample mean: $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$

Geometric mean: $G = \sqrt[n]{x_1 x_2 \cdots x_n}$

Growth rate: $GR = \sqrt[n-1]{\frac{x_n}{x_1}} - 1$

Range: $\text{Range} = x_{\max} - x_{\min}$

Midrange: $\text{Midrange} = \frac{x_{\max} + x_{\min}}{2}$

Sample standard deviation: $s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$

Chapter Review

Each chapter has a list of questions for student self-review or for discussion.

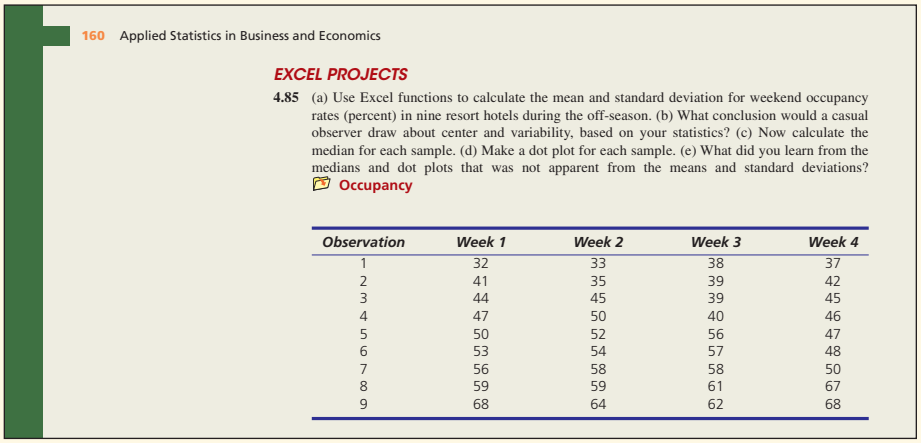
CHAPTER REVIEW

1. Define (a) data, (b) data set, (c) observation, and (d) variable.
2. How do business data differ from scientific experimental data?
3. Distinguish (a) univariate, bivariate, and multivariate data; (b) discrete and continuous data; (c) numerical and categorical data.
4. Define the four measurement levels and give an example of each.
5. Explain the difference between cross-sectional data and time series data.

STUDENT LEARNING?

Chapter Exercises

Exercises give students an opportunity to test their understanding of the chapter material. Exercises are included at the ends of sections and at the ends of chapters. Some exercises contain data sets, identified by data set icons. Data sets can be accessed through Connect and used to solve problems in the text.



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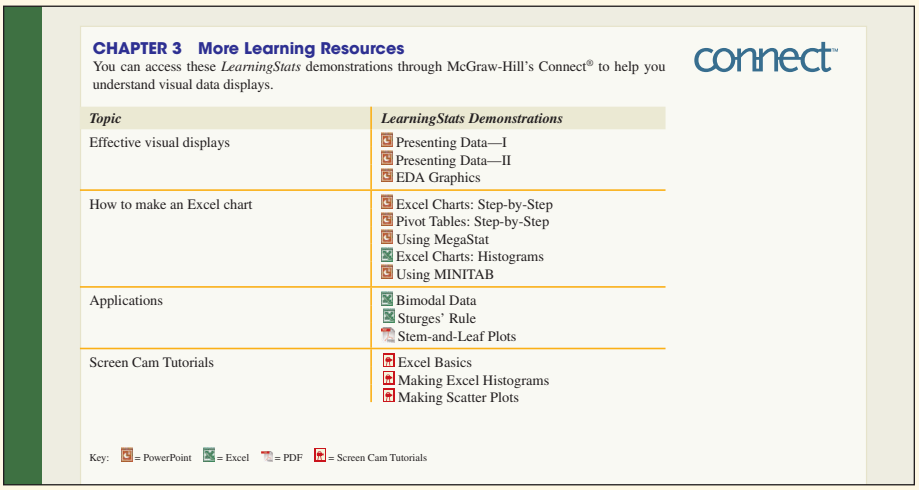
EXCEL PROJECTS

4.85 (a) Use Excel functions to calculate the mean and standard deviation for weekend occupancy rates (percent) in nine resort hotels during the off-season. (b) What conclusion would a casual observer draw about center and variability, based on your statistics? (c) Now calculate the median for each sample. (d) Make a dot plot for each sample. (e) What did you learn from the medians and dot plots that was not apparent from the means and standard deviations?
Occupancy

Observation	Week 1	Week 2	Week 3	Week 4
1	32	33	38	37
2	41	35	39	42
3	44	45	39	45
4	47	50	40	46
5	50	52	56	47
6	53	54	57	48
7	56	58	58	50
8	59	59	61	67
9	68	64	62	68

More Learning Resources

LearningStats provides a means for *Connect* users to explore data and concepts at their own pace. Applications that relate to the material in the chapter are identified by topic at the end of each chapter.



CHAPTER 3 More Learning Resources

You can access these *LearningStats* demonstrations through McGraw-Hill's Connect® to help you understand visual data displays.

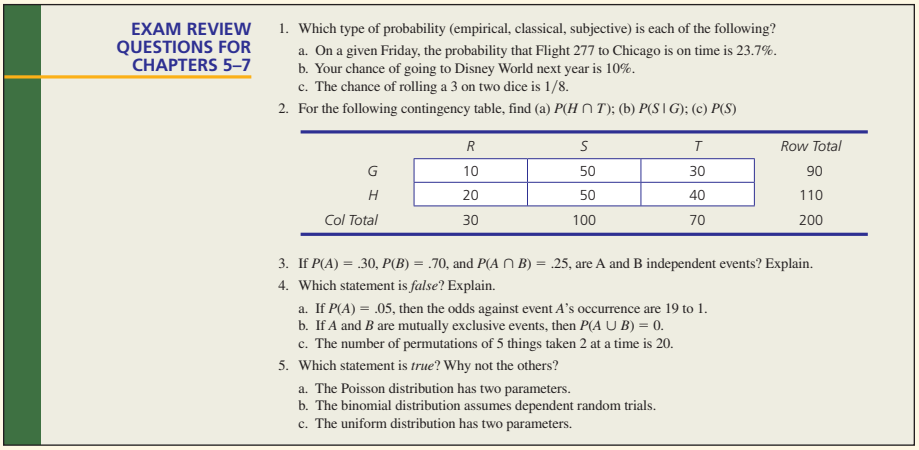
connect™

Topic	*LearningStats Demonstrations*
Effective visual displays	Presenting Data—I Presenting Data—II EDA Graphics
How to make an Excel chart	Excel Charts: Step-by-Step Pivot Tables: Step-by-Step Using MegaStat Excel Charts: Histograms Using MINITAB
Applications	Bimodal Data Sturges' Rule Stem-and-Leaf Plots
Screen Cam Tutorials	Excel Basics Making Excel Histograms Making Scatter Plots

Key: = PowerPoint = Excel = PDF = Screen Cam Tutorials

Exam Review Questions

At the end of a group of chapters, students can review the material they covered in those chapters. This provides them with an opportunity to test themselves on their grasp of the material.



EXAM REVIEW QUESTIONS FOR CHAPTERS 5–7

1. Which type of probability (empirical, classical, subjective) is each of the following?
   a. On a given Friday, the probability that Flight 277 to Chicago is on time is 23.7%.
   b. Your chance of going to Disney World next year is 10%.
   c. The chance of rolling a 3 on two dice is 1/8.
2. For the following contingency table, find (a) $P(H \cap T)$; (b) $P(S \mid G)$; (c) $P(S)$

	R	*S*	*T*	*Row Total*
G	10	50	30	90
H	20	50	40	110
Col Total	30	100	70	200

3. If $P(A) = .30$, $P(B) = .70$, and $P(A \cap B) = .25$, are A and B independent events? Explain.
4. Which statement is *false*? Explain.
   a. If $P(A) = .05$, then the odds against event *A*'s occurrence are 19 to 1.
   b. If *A* and *B* are mutually exclusive events, then $P(A \cup B) = 0$.
   c. The number of permutations of 5 things taken 2 at a time is 20.
5. Which statement is *true*? Why not the others?
   a. The Poisson distribution has two parameters.
   b. The binomial distribution assumes dependent random trials.
   c. The uniform distribution has two parameters.

WHAT TECHNOLOGY CONNECTS STUDENTS

McGraw-Hill's Connect Business Statistics

Less Managing. More Teaching. Greater Learning. McGraw-Hill's *Connect Business Statistics* is an online assignment and assessment solution that connects students with the tools and resources they'll need to achieve success.

McGraw-Hill's *Connect Business Statistics* helps prepare students for their future by enabling faster learning, more efficient studying, and higher retention of knowledge.

McGraw-Hill's* Connect Business Statistics *Features *Connect Business Statistics* offers a number of powerful tools and features to make managing assignments easier, so faculty can spend more time teaching. With *Connect Business Statistics*, students can engage with their coursework anytime and anywhere, making the learning process more accessible and efficient. *Connect Business Statistics* offers you the features described below.

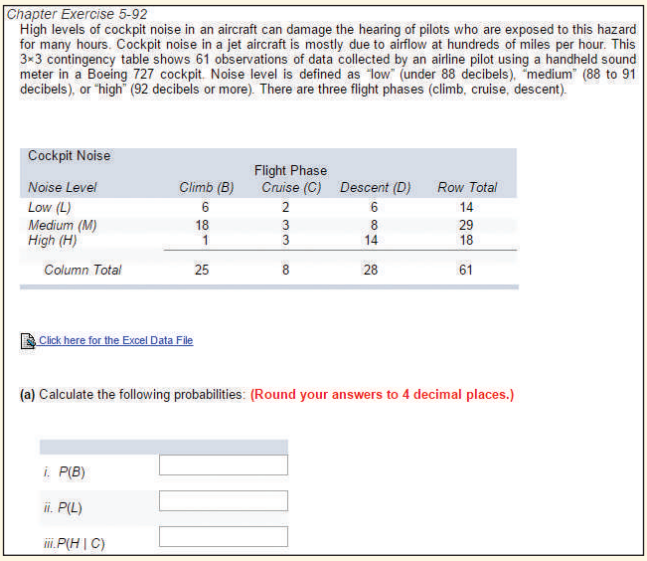
Simple Assignment Management With *Connect Business Statistics*, creating assignments is easier than ever, so you can spend more time teaching and less time managing. The assignment management function enables you to:

- Create and deliver assignments easily with selectable end-of-chapter questions and test bank items.
- Streamline lesson planning, student progress reporting, and assignment grading to make classroom management more efficient than ever.
- Go paperless with the eBook and online submission and grading of student assignments.

Smart Grading When it comes to studying, time is precious. *Connect Business Statistics* helps students learn more efficiently by providing feedback and practice material when they need it, where they need it. When it comes to teaching, your time also is precious. The grading function enables you to:

- Have assignments scored automatically, giving students immediate feedback on their work and side-by-side comparisons with correct answers.
- Access and review each response; manually change grades or leave comments for students to review.
- Reinforce classroom concepts with practice tests and instant quizzes.

Excel Data Sets A convenient feature is the inclusion of an Excel data file link in many problems using data files in their calculation. The link allows students to easily launch into Excel, work the problem, and return to *Connect* to key in the answer.



Chapter Exercise 5-92

High levels of cockpit noise in an aircraft can damage the hearing of pilots who are exposed to this hazard for many hours. Cockpit noise in a jet aircraft is mostly due to airflow at hundreds of miles per hour. This 3×3 contingency table shows 61 observations of data collected by an airline pilot using a handheld sound meter in a Boeing 727 cockpit. Noise level is defined as "low" (under 88 decibels), "medium" (88 to 91 decibels), or "high" (92 decibels or more). There are three flight phases (climb, cruise, descent).

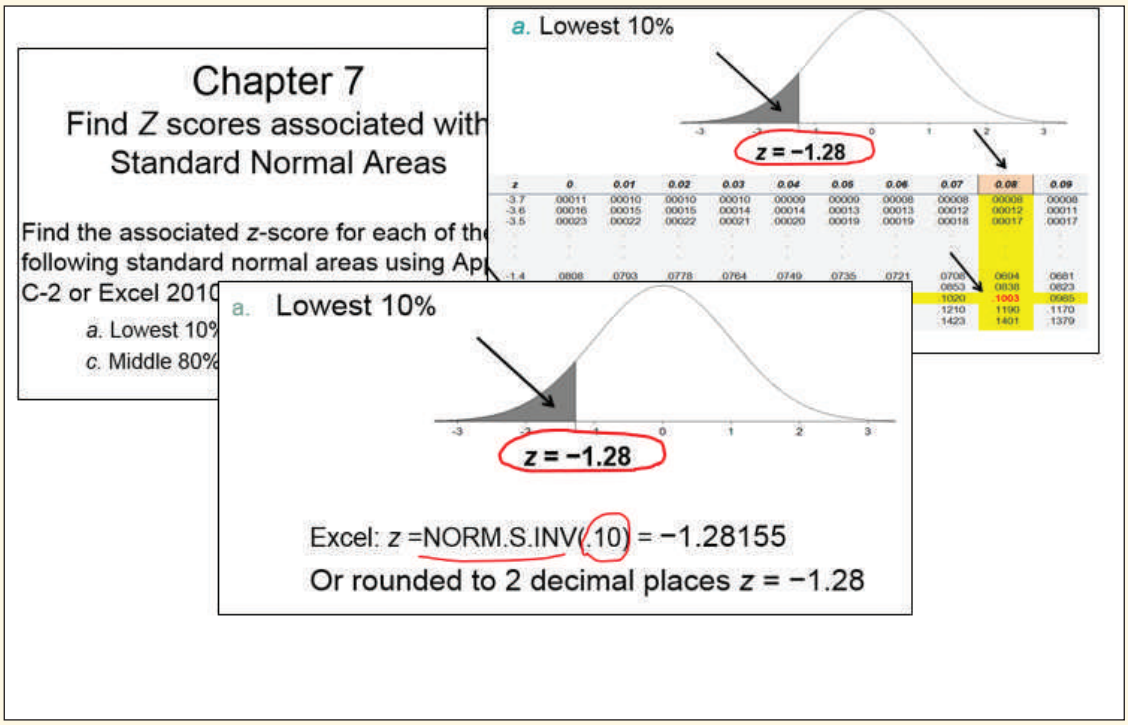
Cockpit Noise	Flight Phase			
Noise Level	*Climb (B)*	*Cruise (C)*	*Descent (D)*	*Row Total*
Low (L)	6	2	6	14
Medium (M)	18	3	8	29
High (H)	1	3	14	18
Column Total	25	8	28	61

Click here for the Excel Data File

(a) Calculate the following probabilities: **(Round your answers to 4 decimal places.)**

i. $P(B)$	
ii. $P(L)$	
iii. $P(H \mid C)$	

Guided Examples These narrated video walkthroughs provide students with step-by-step guidelines for solving selected exercises similar to those contained in the text. The student is given personalized instruction on how to solve a problem by applying the concepts presented in the chapter. The narrated voiceover shows the steps to take to work through an exercise. Students can go through each example multiple times if needed.



Instructor Library The *Connect Business Statistics* Instructor Library is your repository for additional resources to improve student engagement in and out of class. You can select and use any asset that enhances your lecture. The *Connect Business Statistics* Instructor Library includes all of the instructor supplements for this text:

- Solutions Manual
- Test Bank
- PowerPoint Presentations
- Digital Image Library

Diagnostic and Adaptive Learning of Concepts: LearnSmart Students want to make the best use of their study time. The LearnSmart adaptive self-study technology within *Connect Business Statistics* provides students with a seamless combination of practice, assessment, and remediation for every concept in the textbook. LearnSmart's intelligent software adapts

to every student response and automatically delivers concepts that advance students' understanding while reducing time devoted to the concepts already mastered. The result for every student is the fastest path to mastery of the chapter concepts. LearnSmart:

- 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.
- Integrates diagnostics as part of the learning experience.
- Enables you to assess which concepts students have efficiently learned on their own, thus freeing class time for more applications and discussion.

Smartbook Smartbook is an extension of LearnSmart—an adaptive eBook that helps students focus their study time more effectively. As students read, Smartbook assesses comprehension and dynamically highlights where they need to study more.

Student Progress Tracking *Connect Business Statistics* keeps instructors informed about how each student, section, and class is performing, allowing for more productive use of lecture and office hours. The progress-tracking function enables you to:

- View scored work immediately and track individual or group performance with assignment and grade reports.
- Access an instant view of student or class performance relative to learning objectives.
- Collect data and generate reports required by many accreditation organizations, such as AACSB.

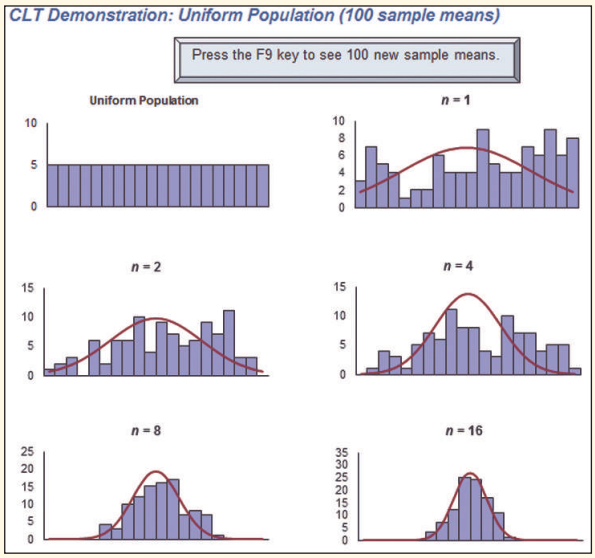
For more information about Connect, go to **connect.mheducation.com**, or contact your local McGraw-Hill sales representative.

WHAT RESOURCES ARE AVAILABLE FOR STUDENTS?

The following software tools are available to assist students in understanding concepts and solving problems.

LearningStats

LearningStats allows students to explore data and concepts at their own pace. It includes demonstrations, simulations, and tutorials that can be downloaded from Connect.



MegaStat® for Excel®

Access Card (ISBN: 0077426274) or online purchase at www.mhhe.com/megastat.

MegaStat is a full-featured Excel add-in 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.

MegaStat output is carefully formatted, and ease-of-use features include Auto Expand for quick data selection and Auto Label detect. Since *MegaStat* is easy to use, students can focus on learning statistics without being distracted by the software. *MegaStat* is always available from Excel's main menu. Selecting a menu item pops up a dialog box. *MegaStat* is updated continuously to work with the latest versions of Excel for Windows and Macintosh users.

Minitab®

Free trials and academic versions are available from Minitab at **www.minitab.com**.

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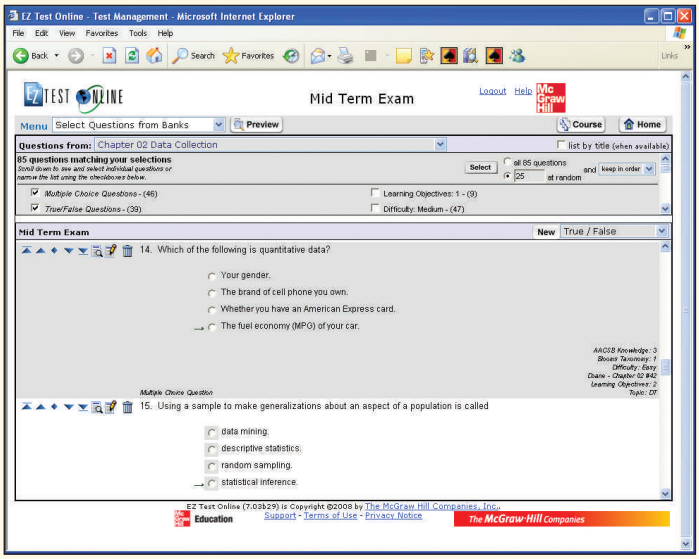
WHAT RESOURCES ARE AVAILABLE FOR INSTRUCTORS?

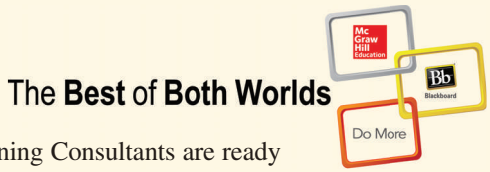
Instructor resources are available through the Connect course at connect.mheducation.com. Resources include: a complete Instructor's Manual in Word format, the complete Test Bank in both Word files and computerized EZ Test format, Instructor PowerPoint slides, text art files, and more.



EZ TEST Online

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, topic, chapter learning objective, Bloom's taxonomy question type, and AACSB knowledge category.

Online Course Management



No matter what online course management system you use (WebCT, Blackboard, or eCollege), we have a course content ePack available for your course. Our new ePacks are specifically designed to make it easy for students to navigate and access content online. For help, our online Digital Learning Consultants are ready to assist you with your online course needs. They provide training and will answer any questions you have throughout the life of your adoption.

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ACKNOWLEDGMENTS

The authors would like to acknowledge some of the many people who have helped with this book. Thomas W. Lauer and Floyd G. Willoughby permitted quotation of a case study. Morgan Elliott, Karl Majeske, Robin McCutcheon, Kevin Murphy, John Sase, T. J. Wharton, and Kenneth M. York permitted questionnaires to be administered in their classes. Mark Isken, Ron Tracy, and Robert Kushler gave generously of their time as expert statistical consultants. Jonathan G. Koomey of E.O. Lawrence Berkeley National Laboratory offered valuable suggestions on visual data presentation.

Mark Isken has reliably provided Excel expertise and has suggested health care applications for examples and case studies. John Seeley and Jeff Whitbey provided regression databases. John Savio and the Michigan State Employees Credit Union provided ATM data. The Siena Research Institute has made its poll results available. J.D. Power and Associates generously provided permission to use vehicle quality data. The Public Interest Research Group of Michigan (PIRGIM) has generously shared data from its field survey of prescription drug prices.

We owe special thanks to Aaron Kennedy and Dave Boennighausen of Noodles & Company, to Mark Gasta, Anja Wallace, and Clifton Pacaro of Vail Resorts, to Jim Curtin and Gordon Backman of Ball Corporation, and to Santosh Lakhan from The Verdeo Group for providing suggestions and access to data for mini cases and examples. For reviewing the material on quality, we wish to thank Kay Beauregard, administrative director at William Beaumont Hospital, and Ellen Barnes and Karry Roberts of Ford Motor Company. Amy Sheikh provided a new Facebook Friends data set, along with other excellent suggestions.

A special debt of gratitude is due to Michele Janicek for her direction and support and Christina Holt for coordinating the project. Thanks to Lloyd Jasingh, Morehead State University, for updating the PowerPoint slides. Special thanks to the accuracy checkers: Kevin Schaub and Christine Brooks, University of Colorado. Thanks to the many reviewers who provided such valuable feedback including criticism that made the book better, some of whom reviewed several drafts of the manuscript. Any remaining errors or omissions are the authors' responsibility. Thanks too, to the participants in our focus groups and symposia on teaching business statistics, who have provided so many teaching ideas and insights into their particular students and courses. We hope you will be able to see in the book and the teaching package consideration of those ideas and insights.

Sung Ahn, *Washington State University*
Mostafa Aminzadeh, *Towson University*
Scott Bailey, *Troy University*
Hope Baker, *Kennesaw State University*
Saad Taha Bakir, *Alabama State University*
Katherine Broneck, *Pima Community College—Downtown*
Mary Beth Camp, *Indiana University—Bloomington*
Alan Cannon, *University of Texas—Arlington*
Deborah Carter, *Coahoma Community College*
Michael Cervetti, *University of Memphis*
Alan Chesen, *Wright State University*
Chia-Shin Chung, *Cleveland State University*
Joseph Coleman, *Wright State University—Dayton*
Robert Cutshall, *Texas A&M University—Corpus Christi*
Terry Dalton, *University of Denver*
Douglas Dotterweich, *East Tennessee State University*
Michael Easley, *University of New Orleans*
Mark Farber, *University of Miami*
Soheila Kahkashan Fardanesh, *Towson University*
Mark Ferris, *St. Louis University*
Stergios Fotopoulos, *Washington State University*
Vickie Fry, *Westmoreland County Community College*
Joseph Fuhr, *Widener University*
Bob Gillette, *University of Kentucky*
Don Gren, *Salt Lake City Community College*
Clifford Hawley, *West Virginia University*
Natalie Hegwood, *Sam Houston State University*
Alam M. Imam, *University of Northern Iowa*
Marc Isaacson, *Augsburg College*
Kishen Iyengar, *University of Colorado—Boulder*
Christopher Johnson, *University of North Florida*
Jerzy Kamburowski, *University of Toledo*
Bob Kitahara, *Troy University*
Drew Koch, *James Madison University*
Bob Lynch, *University of Northern Colorado*
Bradley McDonald, *Northern Illinois University*
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James E. Moran, Jr., *Oregon State University*
Geraldine Moultine, *Northwood University*
Joshua Naranjo, *Western Michigan University*
Anthony Narsing, *Macon State College*
Pin Ng, *Northern Arizona University*
Thomas Obremski, *University of Denver*
Mohammad Reza Oskoorouchi, *California State University—San Marcos*
Mahour Mellat Parast, *University of North Carolina—Pembroke*
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John Pickett, *University of Arkansas—Little Rock*
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Stephan Pollard, *California State University—Los Angeles*
Tammy Prater, *Alabama State University*
Michael Racer, *University of Memphis*
Azar Raiszadeh, *Chattanooga State Community College*
Sue Schou, *Idaho State University*
Sankara N. Sethuraman, *Augusta State University*
Thomas R. Sexton, *Stony Brook University*
Murali Shanker, *Kent State University*
Gary W. Smith, *Florida State University*
Courtenay Stone, *Ball State University*
Paul Swanson, *Illinois Central College*
Deborah Tesch, *Xavier University*
Dharma S. Thiruvaiyaru, *Augusta State University*
Jesus M. Valencia, *Slippery Rock University*
Rachel Webb, *Portland State University*
Simone A. Wegge, *City University of New York*
Alan Wheeler, *University of Missouri—St. Louis*
Blake Whitten, *University of Iowa*
Charles Wilf, *Duquesne University*
Janet Wolcutt, *Wichita State University*
Ye Zhang, *Indiana University—Purdue University Indianapolis*
Mustafa R. Yilmaz, *Northeastern University*

ENHANCEMENTS FOR DOANE/

Many of the following changes were motivated by advice from reviewers and users of the textbook, with special focus on compatibility with *Connect* and *LearnSmart*. Besides hundreds of small edits, six changes were common to all chapters:

- Revised learning objectives to match section content.
- Improved alignment of section headings and key terms.
- Closer compatibility with *Connect* and *LearnSmart*.
- Updated *Related Readings* and *Web Sources* for students who want to "dive deeper."
- Updated *LearningStats* demonstrations (McGraw-Hill Connect® downloads) to illustrate concepts interactively.

Chapter 1—Overview of Statistics

New discussion of jobs for data scientists.

Improved organization of section on critical thinking and fallacies.

Updated *Related Reading* references.

Chapter 2—Data Collection

Revised presentation on variables, data types, and measurement levels.

Reorganized presentation of samples and populations.

Improved visuals on sampling from a population with unknown parameters.

Revised section on sampling methods.

Exercises: five new, five deleted, five revised.

Updated *Related Reading* references.

Two new *LearningStats* demos.

Chapter 3—Describing Data Visually

Learning objectives broken down to give more control by topic.

Revised discussion on binning in frequency distributions.

Twelve new screen shots and guidance for Excel 2013 charts, histograms, and pivot tables.

Four new screen shots and step-by-step guidance for scatter plots.

New screen shots for using Minitab 16 and MegaStat 2013.

Clarification of column vs. bar chart terminology in Excel.

Four updated exercises (transplants, housing starts, lightning deaths, school spending).

Deleted two less-used exercises.

Updated *Related Reading* references.

Chapter 4—Descriptive Statistics

New Excel 2013 screen shots for car defects examples and calculations.

Updated MegaStat 2013 screen shots and instructions.

Improved graphs and visual displays.

Six new practice exercise data sets on central tendency.

Two new practice exercises on variation.

Two new practice exercises on standardized z-scores.

Two new practice exercises on quartiles and fences.

Two new exercises using grouped data.

Two new practice problems on descriptive statistics.

Two new context exercises on describing data sets.

Deleted four less-used exercises.

New decision diagram to guide student choice of statistics and visual displays.

Four updated real data sets for Excel analysis.

Chapter 5—Probability

Four new practice exercises on independence.

Replaced MiniCase 5.1 with new MiniCase on women-owned companies.

Replaced MiniCase 5.3 with new MiniCase decision analysis using Bayes' Theorem.

Chapter 6—Discrete Probability Distributions

Revised expected value and variance topics and moved them to a stand-alone section.

Revised learning objectives to match testable topics more closely.

Four new exercises using CDF, PDF, and expected value.

Deleted four less-used exercises.

Reworded exercises to focus more precisely on testable topics.

One new *LearningStats* actuarial example on life expectancy.

Chapter 7—Continuous Probability Distributions

Revised learning objectives to match topics more closely.

New tip on usage of $<$ versus $\leq$ notation in continuous probability events.

Modest updating of exercises.

Chapter 8—Sampling Distributions and Estimation

Reorganization of sections on CLT, sampling error, and estimation.

Revised learning objectives to better match testable terms and concepts.

Improved graphic for GMAT sampling and parameter vs. statistic.

Simplified discussion of properties of estimators and CLT illustrations.

Reorganized exercises on sampling error and CLT.

Two new exercises on standard error and proportion normality criterion.

Deleted two older exercises.

Improved discussion of finite population correction.

Replaced two end-of-chapter exercises with better ones.

Updated *Related Reading* references.

Chapter 9—One-Sample Hypothesis Tests

Reorganized with two new sections (Type I and Type II error, decision rules).

Improved explanations and visuals for p-values and z-values.

Two new exercises on hypothesis formulation and testing.

Three new *LearningStats* demonstrations.

Chapter 10—Two-Sample Hypothesis Tests

Simplified learning objectives to match content more closely.

Improved notation for tests of two proportions and F-tests.

Replaced fire truck example (new example on reducing hospital cost).

Revised five exercises to improve focus and Connect compatibility.

Replaced one exercise with an "A/B split-testing" proportion exercise.

Added four new end-of-chapter exercises, including two paired t tests.

Chapter 11—Analysis of Variance

Improved notation and illustrations for one-factor ANOVA.

Improved notation and presentation of Tukey's test.

Streamlined discussion of two-factor ANOVA.

Improved graphics and screen shots.

Chapter 12—Simple Regression

Reorganized learning objectives to focus more sharply on testable concepts.

Updated several data sets.

Simplified exposition and improved graphics, labels, and "Tip" headings.

Replaced two data sets with new ones (home values, 2014 vehicle MPG).

Added a new *LearningStats* demonstration (confidence intervals simulation).

Chapter 13—Multiple Regression

Minor edits and improved "Tip" headings.

Substantially increased coverage of logistic regression, with sample printouts.

New multiple regression data set (2014 vehicle MPG with several predictors).

One new logistic regression exercise data set.

Updated *Related Reading* references.

Chapter 14—Time Series Analysis

Simplified exponential smoothing discussion.

New *LearningStats* demonstration on exponential smoothing weights.

Updated *Related Reading* references.

Chapter 15—Chi-Square Tests

Reorganized learning objectives to better align with concepts and with *Connect*.

Improved discussion of chi-square tests using built-in Excel functions.

Replaced two contingency table exercises.

Streamlined discussion of Poisson and normal GOF tests.

Simplified five contingency table exercises to sharpen the focus on key concepts.

Deleted two Poisson mini-projects.

Added two new *LearningStats* demonstrations on chi-square tests.

Chapter 16—Nonparametric Tests

Modified the restaurant quality illustration of the Mann-Whitney/Wilcoxon test.

Clarified the two alternative methods for Mann-Whitney/Wilcoxon test.

Updated several exercises and *Related Readings*.

Chapter 17—Quality Management

Modified learning objectives to permit more precise testing of terms and concepts.

Updated *Related Reading* references.

Chapter 18—Simulation

No changes.

BRIEF CONTENTS

CONTENTS

Applied Statistics

in Business and Economics

Fifth Edition

CHAPTER 1

Overview of Statistics

CHAPTER CONTENTS

CHAPTER LEARNING OBJECTIVES

LO

When you finish this chapter you should be able to

- **LO 1-1** Define statistics and explain some of its uses.
- **LO 1-2** List reasons for a business student to study statistics.
- **LO 1-3** Explain the uses of statistics in business.
- **LO 1-4** State the common challenges facing business professionals using statistics.
- **LO 1-5** List and explain common statistical pitfalls.

Prelude

When managers are well informed about a company's internal operations (e.g., sales, production, inventory levels, time to market, warranty claims) and competitive position (e.g., market share, customer satisfaction, repeat sales) they can take appropriate actions to improve their business. Managers need reliable, timely information so they can analyze market trends and adjust to changing market conditions. Better data can also help a company decide which types of strategic information they should share with trusted business partners to improve their supply chain. *Statistics* and *statistical analysis* permit *data-based decision making* and reduce managers' need to rely on guesswork.

Statistics is a key component of the field of *business intelligence,* which encompasses all the technologies for collecting, storing, accessing, and analyzing data on the company's operations in order to make better business decisions. Statistics helps convert unstructured "raw" data (e.g., point-of-sale data, customer spending patterns) into *useful information* through online analytical processing (OLAP) and data mining, terms that you may have encountered in your other business classes. Statistical analysis focuses attention on key problems and guides discussion toward issues, not personalities or territorial struggles. While powerful database software and query systems are the key to managing a firm's data warehouse, relatively small Excel spreadsheets are often the focus of discussion among managers when it comes to "bottom line" decisions. That is why Excel is featured prominently in this textbook.

In short, companies increasingly are using *business analytics* to support decision making, to recognize anomalies that require tactical action, or to gain strategic insight to align business processes with business objectives. Answers to questions such as "How likely is this event?" or "What if this trend continues?" will lead to appropriate actions. Businesses that combine managerial judgment with statistical analysis are more successful.

1.1 WHAT IS STATISTICS?

LO 1-1

Define statistics and explain some of its uses.

Statistics is the science of collecting, organizing, analyzing, interpreting, and presenting data. Some experts prefer to call statistics **data science**, a trilogy of tasks involving data modeling, analysis, and decision making. A **statistic** is a single measure, reported as a number, used to

summarize a sample data set. Statistics may be thought of as a collection of methodologies to summarize, draw valid conclusions, and make predictions from empirical measurements. Statistics helps us organize and present information and extract meaning from raw data. Although it is often associated with the sciences and medicine, statistics is now used in every academic field and every area of business.

Plural or Singular?

Statistics The science of collecting, organizing, analyzing, interpreting, and presenting data.

Statistic A single measure, reported as a number, used to summarize a sample data set.

Many different measures can be used to summarize data sets. You will learn throughout this textbook that there can be different measures for different sets of data and different measures for different types of questions about the same data set. Consider, for example, a sample data set that consists of heights of students in a university. There could be many different uses for this data set. Perhaps the manufacturer of graduation gowns wants to know how long to make the gowns; the best *statistic* for this would be the *average* height of the students. But an architect designing a classroom building would want to know how high the doorways should be, and would base measurements on the *maximum* height of the students. Both the average and the maximum are examples of a *statistic*.

You may not have a trained statistician in your organization, but any college graduate is expected to know something about statistics, and anyone who creates graphs or interprets data is "doing statistics" without an official title.

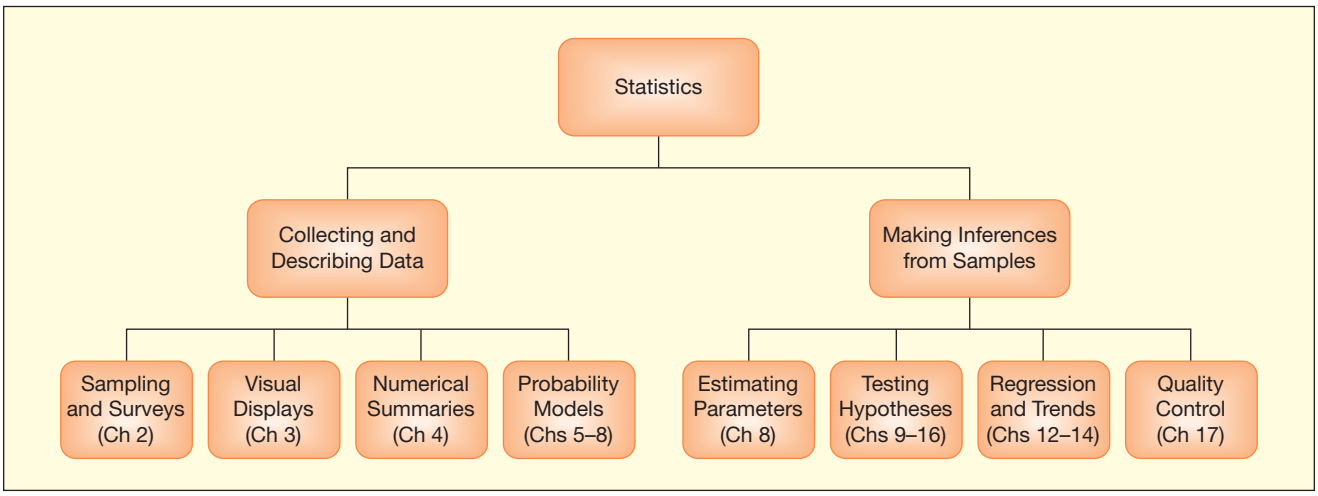
There are two primary kinds of statistics:

- **Descriptive statistics** refers to the collection, organization, presentation, and summary of data (either using charts and graphs or using a numerical summary).
- **Inferential statistics** refers to generalizing from a sample to a population, estimating unknown population parameters, drawing conclusions, and making decisions.

Figure 1.1 identifies the tasks and the text chapters for each.

FIGURE 1.1

Overview of Statistics



Mini Case 1.1

Vail Resorts

What do the following experiences have in common with *statistics:* an epic ski down a snowy mountain, a superb day of golf, a restful night's sleep, and plentiful clean water for wildlife? Vail Resorts, Inc., has been successfully providing these experiences through the use of rigorous data analysis.

How does Vail Resorts achieve growth? One way is to increase ski lift ticket revenue. Prior to the 2008/2009 ski season, Vail Resorts management asked their marketing group to figure out how to increase the number of annual visits from their destination guests. Customer surveys indicated that having more flexibility around vacation planning would increase the chance that they visited more than once per year. A new season pass of some sort that allowed multiple ski days throughout the ski season was one possible solution. Vail Resorts currently offers The Colorado Pass, which is attractive to in-state guests. But this pass product was not available to out-of-state guests. Vail Resorts needed answers to questions such as: Which resorts should be included on the pass? How many ski days should the pass offer? Should there be blackout dates or not? What price would make the pass attractive?

Four market surveys were sent out to random samples of current and potential guests, including out-of-state guests, in-state guests, and Vail Valley residents. The responses were then used in a statistical analysis to determine relative importance of the various pass features so that the optimal pass product could be offered. What the Vail Resorts marketing team found was that guests were most concerned about the pass price but still wanted to be able to ski at all five ski areas owned by Vail Resorts: Vail, Beaver Creek, Breckenridge, Keystone, and Heavenly. Guests also wanted unlimited days of skiing at Vail and Beaver Creek, and did not want any dates blacked out.

The Epic Pass was first offered for sale on March 18, 2008, for a price of $579. Customers kept their word. By December 9, 2008, over 59,000 Epic Passes had been purchased for total sales revenue of $32.5 million. The number of total passes sold had increased by 18 percent and total pass revenue had increased by 29 percent over the previous pass sales season.

In the following chapters, look for examples and exercises to learn more about how Vail Resorts uses data analysis and statistics to:

- Decrease waiting times to purchase lift tickets.
- Maintain a healthy ratio of out-of-state to in-state guests.

- Help guests feel safe on the mountain.
- Keep hotel rooms booked.
- Increase the percentage of employees who return each season.
- Ensure a healthy environment for wildlife at Grand Teton National Park.

1.2 WHY STUDY STATISTICS?

LO 1-2

List reasons for a business student to study statistics.

A 2006 *BusinessWeek* article called statistics and probability "core skills for businesspeople" in order to know when others are dissembling, to build financial models, or to develop a marketing plan. This same report also said that "B-school grads with strong calculus will find far more opportunities." Each year, *The Wall Street Journal* asks corporate recruiters to rate U.S. business schools on various attributes. In a 2006 *WSJ* survey, recruiters said that the top five attributes were (1) communication and interpersonal skills; (2) ability to work well within a team; (3) personal ethics and integrity; (4) analytical and problem-solving skills; and (5) work ethic. (See "Why Math Will Rock Your World," *BusinessWeek,* January 23, 2006, p. 60; and *The Wall Street Journal,* Sept. 20, 2006.)

Data Skills Count

"We look to recruit and groom leaders in our organization who possess strong quantitative skills in addition to a passion for what we do—delivering exceptional experiences at our extraordinary resorts every day. Knowing how to use and interpret data when making important business decisions is one of the keys to our Company's success."

Rob Katz, chairman and chief executive officer of Vail Resorts

Knowing statistics will make you a better consumer of other people's data analyses. You should know enough to handle everyday data problems, to feel confident that others cannot deceive you with spurious arguments, and to know when you've reached the limits of your expertise. Statistical knowledge gives your company a competitive advantage versus those that cannot understand their internal or external market data. Mastery of basic statistics gives you, the individual manager, a competitive advantage as you work your way through the promotion process, or when you move to a new employer. For specialized training, many universities now offer masters degrees in business analytics. But here are some reasons for anyone to study statistics.

Communication The language of statistics is widely used in science, social science, education, health care, engineering, and even the humanities. In all areas of business (accounting, finance, human resources, marketing, information systems, operations management), workers use statistical jargon to facilitate communication. In fact, statistical terminology has reached the highest corporate strategic levels (e.g., "Six Sigma" at GE and Motorola). And in the multinational environment, the specialized vocabulary of statistics permeates language barriers to improve problem solving across national boundaries.

Computer Skills Whatever your computer skill level, it can be improved. Every time you create a spreadsheet for data analysis, write a report, or make an oral presentation, you bring together skills you already have, and learn new ones. Specialists with advanced training design the databases and decision support systems, but you must handle daily data problems *without* experts. Besides, you can't always find an "expert," and, if you do, the "expert" may not understand your application very well. You need to be able to analyze data, use software with confidence, prepare your own charts, write your own reports, and make electronic presentations on technical topics.

Information Management Statistics can help you handle either too little or too much information. When insufficient data are available, statistical surveys and samples can be used

to obtain the necessary market information. But most large organizations are closer to drowning in data than starving for it. Statistics can help summarize large amounts of data and reveal underlying relationships. You've heard of data mining? Statistics is the pick and shovel that you take to the data mine.

Technical Literacy Many of the best career opportunities are in growth industries propelled by advanced technology. Marketing staff may work with engineers, scientists, and manufacturing experts as new products and services are developed. Sales representatives must understand and explain technical products like pharmaceuticals, medical equipment, and industrial tools to potential customers. Purchasing managers must evaluate suppliers' claims about the quality of raw materials, components, software, or parts.

Process Improvement Large manufacturing firms like Boeing or Toyota have formal systems for continuous quality improvement. The same is true of insurance companies and financial service firms like Vanguard or Fidelity, and the federal government. Statistics helps firms oversee their suppliers, monitor their internal operations, and identify problems. Quality improvement goes far beyond statistics, but every college graduate is expected to know enough statistics to understand its role in quality improvement.

Mini Case 1.2

Can Statistics Predict Airfares?

When you book an airline ticket online, does it annoy you when the next day you find a cheaper fare on exactly the same flight? Or do you congratulate yourself when you get a "good" fare followed by a price rise? This ticket price volatility led to the creation of a new company called Farecast that examines over 150 billion "airfare observations" and tries to use the data to predict whether or not the fare for a given ticket is likely to rise. The company's prediction accuracy so far is estimated at 61 percent (in independent tests) and 75 percent (the company's tests). In this case, the benchmark is a coin toss (50 percent). The company offers price rise insurance for a small fee. If you travel a lot and like to play the odds, such predictions could save money. With online air bookings at $44 billion, a few dollars saved here and there can add up. (See *Budget Travel,* February 2007, p. 37; and *The New York Times,* "An Insurance Policy for Low Airfares," January 22, 2007, p. C10.)

1.3 STATISTICS IN BUSINESS

LO 1-3

Explain the uses of statistics in business.

You've seen why statistics is important. Now let's look at some of the ways statistics is used in business.

Auditing A large firm pays over 12,000 invoices to suppliers every month. The firm has learned that some invoices are being paid incorrectly, but they don't know how widespread the problem is. The auditors lack the resources to check all the invoices, so they decide to take a sample to estimate the proportion of incorrectly paid invoices. How large should the sample be for the auditors to be confident that the estimate is close enough to the true proportion?

Marketing A marketing consultant is asked to identify likely repeat customers for Amazon.com, and to suggest co-marketing opportunities based on a database containing records of 5 million Internet purchases of books, CDs, and DVDs. How can this large database be mined to reveal useful patterns that might guide the marketing strategy?

Health Care Health care is a major business (1/6 of the U.S. GDP). Hospitals, clinics, and their suppliers can save money by finding better ways to manage patient appointments, schedule procedures, or rotate their staff. For example, an outpatient cognitive retraining clinic for victims of closed-head injuries or stroke evaluates 56 incoming patients using a 42-item

physical and mental assessment questionnaire. Each patient is evaluated independently by two experienced therapists. Are there statistically significant differences between the two therapists' evaluations of incoming patients' functional status? Are some assessment questions redundant? Do the initial assessment scores accurately predict the patients' lengths of stay in the program?

Quality Improvement A manufacturer of rolled copper tubing for radiators wishes to improve its product quality. It initiates a triple inspection program, sets penalties for workers who produce poor-quality output, and posts a slogan calling for "zero defects." The approach fails. Why?

Purchasing A retailer's shipment of 200 DVD players reveals 4 with defects. The supplier's historical defect rate is .005. Has the defect rate really risen, or is this simply a "bad" batch?

Medicine An experimental drug to treat asthma is given to 75 patients, of whom 24 get better. A placebo is given to a control group of 75 volunteers, of whom 12 get better. Is the new drug better than the placebo, or is the difference within the realm of chance?

Operations Management The Home Depot carries 50,000 different products. To manage this vast inventory, it needs a weekly order forecasting system that can respond to developing patterns in consumer demand. Is there a way to predict weekly demand and place orders from suppliers for every item, without an unreasonable commitment of staff time?

Product Warranty A major automaker wants to know the average dollar cost of engine warranty claims on a new hybrid vehicle. It has collected warranty cost data on 4,300 warranty claims during the first six months after the engines are introduced. Using these warranty claims as an estimate of future costs, what is the margin of error associated with this estimate?

Mini Case 1.3

How Do You Sell Noodles with Statistics?

"The best answer starts with a thorough and thoughtful analysis of the data," says Aaron Kennedy, founder of Noodles & Company.

(Visit www.noodles.com to find a Noodles & Company restaurant near you.)

Noodles & Company introduced the *quick casual* restaurant concept, redefining the standard for modern casual dining in the United States in the 21st century. Noodles & Company first opened in Colorado in 1995 and has not stopped growing since. As of June 2014, they had

over 400 restaurants all across the United States from Portland and San Diego to Alexandria and Silver Spring with stops in cities such as Omaha and Naperville.

Noodles & Company has achieved this success with a customer-driven business model and fact-based decision making. Their widespread popularity and high growth rate have been supported by careful consideration of data and thorough statistical analysis that provide answers to questions such as:

- Should we offer continuity/loyalty cards for our customers?
- How can we increase the use of our extra capacity during the dinner hours?
- Which new city should we open in?
- Which location should we choose for the new restaurant?
- How do we determine the effectiveness of a marketing campaign?
- Which meal maximizes the chance that a new customer will return?
- Are rice krispies related to higher sales?
- Does reducing service time increase sales?

Aaron Kennedy, founder of Noodles & Company, says that "using data is the strongest way to inform good decisions. By assessing our internal and external environments on a continuous basis, our Noodles management team has been able to plan and execute our vision."

"I had no idea as a business student that I'd be using statistical analysis as extensively as I do now," says Dave Boennighausen, Chief Financial Officer at Noodles & Company. In the coming chapters, as you learn about the statistical tools businesses use today, look for the Noodles logo 

next to examples and exercises that show how Noodles uses data and statistical methods in its business functions.

SECTION EXERCISES

1.1 Give an example of how statistics might be useful to the person in the scenario.

a. An auditor is looking for inflated broker commissions in stock transactions.
b. An industrial marketer is representing her firm's compact, new low-power OLED screens to the military.
c. A plant manager is studying absenteeism at vehicle assembly plants in three states.
d. An automotive purchasing agent is comparing defect rates in steel shipments from three vendors of steel.

1.2 Give an example of how statistics might be useful to the person in the scenario.

a. A personnel executive is examining job turnover by gender in different restaurants in a fast-food chain.
b. An intranet manager is studying e-mail usage rates by employees in different job classifications.
c. A retirement planner is studying mutual fund performance for six different types of asset portfolios.
d. A hospital administrator is studying surgery scheduling to improve facility utilization rates at different times of day.

1.3 (a) Should the average business school graduate expect to use computers to manipulate data, or is this a job better left to specialists? (b) What problems arise when an employee is weak in quantitative skills? Based on your experience, is that common?

1.4 "Many college graduates will not use very much statistics during their 40-year careers, so why study it?" (a) List several arguments for and against this statement. Which position do you find more convincing? (b) Replace the word "statistics" with "accounting" or "foreign language" and repeat this exercise.

1.5 (a) How much statistics does a student need in *your* chosen field of study? Why not more? Why not less? (b) How can you tell when the point has been reached where you should call for an expert statistician? List some costs and some benefits that would govern this decision.