

# Statistics for Managers

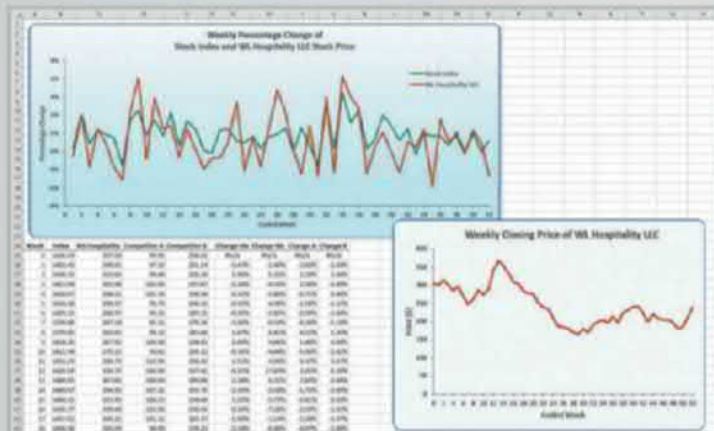
## Using Microsoft® Excel®

9TH EDITION

David M.  
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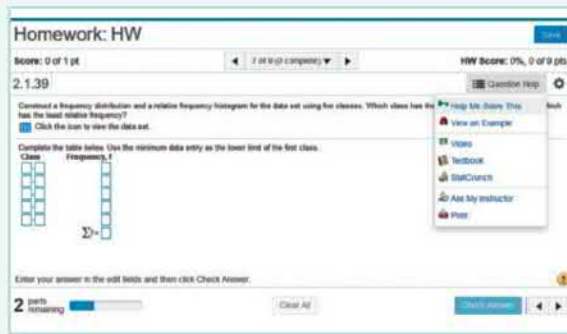
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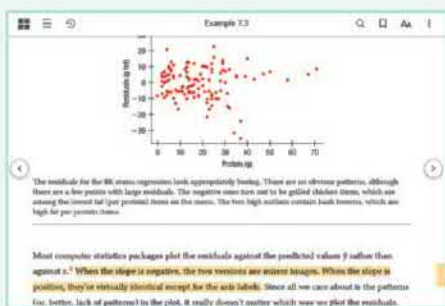
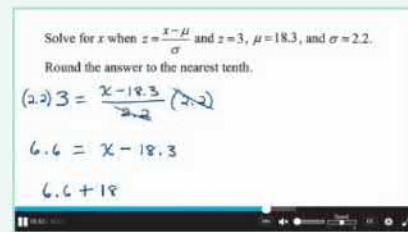


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# A ROADMAP FOR SELECTING A STATISTICAL METHOD

Data Analysis Task	For Numerical Variables	For Categorical Variables
<b>Describing a group or several groups</b>	<p>Ordered array, stem-and-leaf display, frequency distribution, relative frequency distribution, percentage distribution, cumulative percentage distribution, histogram, polygon, cumulative percentage polygon <b>(Sections 2.2, 2.4)</b></p> <p>Mean, median, mode, geometric mean, quartiles, range, interquartile range, standard deviation, variance, coefficient of variation, skewness, kurtosis, boxplot, normal probability plot <b>(Sections 3.1, 3.2, 3.3, 6.3)</b></p> <p>Index numbers <b>(online Section 16.7)</b></p> <p>Dashboards <b>(Section 17.2)</b></p>	<p>Summary table, bar chart, pie chart, doughnut chart, Pareto chart <b>(Sections 2.1 and 2.3)</b></p>
<b>Inference about one group</b>	<p>Confidence interval estimate of the mean <b>(Sections 8.1 and 8.2)</b></p> <p><math>t</math> test for the mean <b>(Section 9.2)</b></p> <p>Chi-square test for a variance or standard deviation <b>(online Section 12.7)</b></p>	<p>Confidence interval estimate of the proportion <b>(Section 8.3)</b></p> <p>Z test for the proportion <b>(Section 9.4)</b></p>
<b>Comparing two groups</b>	<p>Tests for the difference in the means of two independent populations <b>(Section 10.1)</b></p> <p>Wilcoxon rank sum test <b>(Section 12.4)</b></p> <p>Paired <math>t</math> test <b>(Section 10.2)</b></p> <p><math>F</math> test for the difference between two variances <b>(Section 10.4)</b></p> <p>Wilcoxon signed ranks test <b>(online Section 12.8)</b></p>	<p>Z test for the difference between two proportions <b>(Section 10.3)</b></p> <p>Chi-square test for the difference between two proportions <b>(Section 12.1)</b></p> <p>McNemar test for two related samples <b>(online Section 12.6)</b></p>
<b>Comparing more than two groups</b>	<p>One-way analysis of variance for comparing several means <b>(Section 11.1)</b></p> <p>Kruskal-Wallis test <b>(Section 12.5)</b></p> <p>Randomized block design <b>(online Section 11.3)</b></p> <p>Two-way analysis of variance <b>(Section 11.2)</b></p>	<p>Chi-square test for differences among more than two proportions <b>(Section 12.2)</b></p>
<b>Analyzing the relationship between two variables</b>	<p>Scatter plot, time series plot <b>(Section 2.5)</b></p> <p>Covariance, coefficient of correlation <b>(Section 3.5)</b></p> <p>Simple linear regression <b>(Chapter 13)</b></p> <p><math>t</math> test of correlation <b>(Section 13.7)</b></p> <p>Time-series forecasting <b>(Chapter 16)</b></p> <p>Sparklines <b>(Section 2.7)</b></p>	<p>Contingency table, side-by-side bar chart, PivotTables <b>(Sections 2.1, 2.3, 2.6)</b></p> <p>Chi-square test of independence <b>(Section 12.3)</b></p>
<b>Analyzing the relationship between two or more variables</b>	<p>Colored scatter plots, bubble chart, treemap <b>(Section 2.7)</b></p> <p>Multiple regression <b>(Chapters 14 and 15)</b></p> <p>Dynamic bubble charts <b>(Section 17.2)</b></p> <p>Regression trees <b>(Section 17.3)</b></p> <p>Cluster analysis <b>(Section 17.4)</b></p>	<p>Multidimensional contingency tables <b>(Section 2.6)</b></p> <p>Drilldown and slicers <b>(Section 2.7)</b></p> <p>Logistic regression <b>(Section 14.7)</b></p> <p>Classification trees <b>(Section 17.3)</b></p> <p>Multiple correspondence analysis <b>(Section 17.5)</b></p>

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# Statistics for Managers Using Microsoft® Excel®

NINTH EDITION

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*To our spouses and children,  
Marilyn, Mary, Sharyn, and Mark*

*and to our parents, in loving memory,  
Lee, Reuben, Ruth, Francis J., Mary, and William*

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# About the Authors

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*Kathryn Szabat, David Levine, and David Stephan*

**David M. Levine, David F. Stephan, and Kathryn A. Szabat** are all experienced business school educators committed to innovation and improving instruction in business statistics and related subjects.

**David Levine**, Professor Emeritus of Statistics and CIS at Baruch College, CUNY, is a nationally recognized innovator in statistics education for more than three decades. Levine has coauthored 14 books, including several business statistics textbooks; textbooks and professional titles that explain and explore quality management and the Six Sigma approach; and, with David Stephan, a trade paperback that explains statistical concepts to a general audience. Levine has presented or chaired numerous sessions about business education at leading conferences conducted by the Decision Sciences Institute (DSI) and the American Statistical Association, and he

and his coauthors have been active participants in the annual DSI Data, Analytics, and Statistics Instruction (DASI) mini-conference. During his many years teaching at Baruch College, Levine was recognized for his contributions to teaching and curriculum development with the College's highest distinguished teaching honor. He earned B.B.A. and M.B.A. degrees from CCNY, and a Ph.D. in industrial engineering and operations research from New York University.

Advances in computing have always shaped **David Stephan's** professional life. As an undergraduate, he helped professors use statistics software that was considered advanced even though it could compute *only* several things discussed in Chapter 3, thereby gaining an early appreciation for the benefits of using software to solve problems (and perhaps positively influencing his grades). An early advocate of using computers to support instruction, he developed a prototype of a mainframe-based system that anticipated features found today in Pearson's MathXL and served as special assistant for computing to the Dean and Provost at Baruch College. In his many years teaching at Baruch, Stephan implemented the first computer-based *classroom*, helped redevelop the CIS curriculum, and, as part of a FIPSE project team, designed and implemented a multimedia learning environment. He was also nominated for teaching honors. Stephan has presented at SEDSI and DSI DASI mini-conferences, sometimes with his coauthors. Stephan earned a B.A. from Franklin & Marshall College and an M.S. from Baruch College, CUNY, and completed the instructional technology graduate program at Teachers College, Columbia University.

As Associate Professor of Business Systems and Analytics at La Salle University, **Kathryn Szabat** has transformed several business school majors into one interdisciplinary major that better supports careers in new and emerging disciplines of data analysis including analytics. Szabat strives to inspire, stimulate, challenge, and motivate students through innovation and curricular enhancements and shares her coauthors' commitment to teaching excellence and the continual improvement of statistics presentations. Beyond the classroom she has provided statistical advice to numerous business, nonbusiness, and academic communities, with particular interest in the areas of education, medicine, and nonprofit capacity building. Her research activities have led to journal publications, chapters in scholarly books, and conference presentations. Szabat is a member of the American Statistical Association (ASA), DSI, Institute for Operation Research and Management Sciences (INFORMS), and DSI DASI. She received a B.S. from SUNY-Albany, an M.S. in statistics from the Wharton School of the University of Pennsylvania, and a Ph.D. in statistics, with a cognate in operations research, from the Wharton School of the University of Pennsylvania.

For all three coauthors, continuous improvement is a natural outcome of their curiosity about the world. Their varied backgrounds and many years of teaching experience have come together to shape this book in ways discussed in the Preface.

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# Preface

**A**s business statistics evolves and becomes an increasingly important part of one's business education, which topics get taught and how those topics are presented becomes all the more important. As authors, we think about these issues as we seek ways to continuously improve the quality of business statistics education. We actively participate in conferences and meetings sponsored by the Decision Sciences Institute, American Statistical Association (ASA), and INFORMS, the Institute for Operations Research and the Management Sciences. We use the ASA's Guidelines for Assessment and Instruction (GAISE) reports and combine them with our experiences teaching business statistics to a diverse student body at several universities.

When writing a book for introductory business statistics students, four learning principles guide us.

**Help students see the relevance of statistics to their own careers by using examples from the functional areas that may become their areas of specialization.** Students need to learn statistics in the context of the functional areas of business. We discuss every statistical method using an example from a functional area, such as accounting, finance, management, or marketing, and explain the application of methods to specific business activities.

**Emphasize interpretation and analysis of statistical results over calculation.** We emphasize the interpretation of results, the evaluation of the assumptions, and the discussion of what should be done if the assumptions are violated. We believe that these activities are more important to students' futures and will serve them better than emphasizing tedious manual calculations.

**Give students ample practice in understanding how to apply statistics to business.** We believe that both classroom examples and homework exercises should involve actual or realistic data, using small and large sets of data, to the extent possible.

**Integrate data analysis software with statistical learning.** We integrate Microsoft Excel into every statistics method that the book discusses in full. This integration illustrates how software can assist the business decision-making process. In this edition, we also integrate using Tableau into selected topics, where such integration makes best sense. (Integrating data analysis software also supports our second principle about emphasizing interpretation over calculation.)

When thinking about introductory business statistics students using data analysis software, three additional principles guide us.

**Using software should model business best practices.** We emphasize reusable templates and model solutions over building unaudited solutions from scratch that may contain errors. Using preconstructed and previously validated solutions not only models best practice but reflects regulatory requirements that businesses face today.

**Provide detailed sets of instructions that accommodate various levels of software use and familiarity.** Instruction sets should accommodate casual software users and as well as users keen to use software to a deeper level. For most topics, we present *PHStat* and *Workbook* instructions, two different sets that create identical statistical results.

**Software instruction sets should be complete and contain known starting points.** Vague instructions that present statements such as "Use command *X*" that presume students can figure out how to "get to" command *X* are distracting to learning. We provide instruction sets that have a known starting point, typically in the form of "open to a specific worksheet in a specific workbook."

## What's New in This Edition?

This ninth edition of *Statistics for Managers Using Microsoft Excel* features many passages rewritten in a more concise style that emphasize definitions as the foundation for understanding statistical concepts. In addition to changes that readers of past editions have come to expect, such as new examples and Using Statistics case scenarios and an extensive number of new end-of-section or end-of-chapter problems, the edition debuts:

- **Tabular Summaries** that state hypothesis test and regression example results along with the conclusions that those results support now appear in Chapters 10 through 13.
- **Tableau Guides** that explain how to use the data visualization software Tableau Public as a complement to Microsoft Excel for visualizing data and regression analysis.
- **A New Business Analytics Chapter (Chapter 17)** that provides a complete introduction to the field of business analytics. The chapter defines terms and categories that introductory business statistics students may encounter in other courses or outside the classroom. This chapter benefits from the insights the authors have gained from teaching and lecturing about business analytics as well as research the authors have done for a forthcoming companion book on business analytics.

## Continuing Features That Readers Have Come to Expect

This edition of *Statistics for Managers Using Microsoft Excel* continues to incorporate a number of distinctive features that has led to its wide adoption over the previous editions. Table 1 summarizes these carry-over features:

**TABLE 1**  
Distinctive Features Continued in the Ninth Edition

Feature	Details
<b>Using Statistics case scenarios</b>	Each chapter begins with a Using Statistics case scenario that presents a business problem or goal that illustrates the application of business statistics to provide actionable information. For many chapters, scenarios also provide the scaffolding for learning a series of related statistical methods. End-of-chapter “Revisited” sections reinforce the statistical learning of a chapter by discussing how the methods and techniques can be applied to the goal or problem that the case scenario considers. <i>In this edition, seven chapters have new or revised case scenarios.</i>
<b>Emphasis on interpretation of the data analysis results</b>	<i>Statistics for Managers Using Microsoft Excel</i> was among the first introductory business statistics textbooks to focus on the interpretation of Microsoft Excel statistical results. This tradition continues, now supplemented by Tableau (Public) results for selected methods in which Tableau can enhance or complement Excel results.
<b>Software integration and flexibility</b>	Software instructions feature chapter examples and were personally written by the authors, who collectively have more than one hundred years of experience teaching the application of business software. With modularized <i>Workbook</i> , <i>PHStat</i> , and where applicable, <i>Analysis Toolkit</i> instructions, both instructors and students can switch among these instruction sets as they use this book with no loss of statistical learning.
<b>Unique Excel workbooks</b>	<i>Statistics for Managers Using Microsoft Excel</i> comes with Excel Guide workbooks that illustrate model solutions and provide template solutions to selected methods and Visual Explorations, macro-enhanced workbooks that demonstrate selected basic concepts. This book is fully integrated with <i>PHStat</i> , the Pearson statistical add-in for Excel that places the focus on statistical learning that the authors designed and developed. <i>See Appendix H for a complete description of PHStat.</i>



**TABLE 1** Distinctive Features Continued in the Ninth Edition (*continued*)

Feature	Details
<b>In-chapter and end-of-chapter reinforcements</b>	Exhibits summarize key processes throughout the book. A key terms list provides an index to the definitions of the important vocabulary of a chapter. “Learning the Basics” questions test the basic concepts of a chapter. “Applying the Concepts” problems test the learner’s ability to apply statistical methods to business problems. And, for the more mathematically minded, “Key Equations” list the boxed number equations that appear in a chapter.
<b>End-of-chapter cases</b>	End-of-chapter cases include a case that continues through most chapters and several cases that reoccur throughout the book. “Digital Cases” require students to examine business documents and other information sources to sift through various claims and discover the data most relevant to a business case problem. Many of these cases also illustrate common misuses of statistical information.  <i>The Instructor’s Solutions Manual provides instructional tips for using cases as well as solutions to the Digital Cases.</i>
<b>Answers to even-numbered problems</b>	An appendix provides additional self-study opportunities by provides answers to the “Self-Test” problems and most of the even-numbered problems in this book
<b>Opportunities for additional learning</b>	In-margin student tips and LearnMore references reinforce important points and direct students to additional learning resources. In-chapter <i>Consider This</i> essays reinforce important concepts, examine side issues, or answer questions that arise while studying business statistics, such as “What is so ‘normal’ about the normal distribution?”
<b>Highly tailorable content</b>	With an extensive library of separate online topics, sections, and even two full chapters, instructors can combine these materials and the opportunities for additional learning to meet their curricular needs.

## Chapter-by-Chapter Changes Made for This Edition

Because the authors believe in continuous quality improvement, *every* chapter of *Statistics for Managers Using Microsoft Excel* contains changes to enhance, update, or just freshen this book. Table 2 provides a chapter-by-chapter summary of these changes.

**TABLE 2**  
Chapter-by-Chapter  
Change Matrix

Chapter	Using Statistics Changed	Problems Changed	Selected Chapter Changes
First Things First		n.a.	Updates opening section. Retitles, revises, and expands old Section FTF.4 as Section FTF.4 and new Section FTF.5 “Starting Point for Using Microsoft Excel.” Expands the First Things First Excel Guide. Adds a First Things First Tableau Guide.
1		26%	Old Sections 1.3 and 1.4 revised and expanded as new Section 1.4 “Data Preparation.” Adds a Chapter 1 Tableau Guide.
2	•	57%	Uses new samples of 479 retirement funds and 100 restaurant meal costs for in-chapter examples. Includes new examples for organizing and visualizing categorical variables. Uses updated scatter plot and time-series plot examples. Adds new Section 2.8 “Filtering and Querying Data.” Adds coverage of bubble charts, treemaps, and (Tableau) colored scatter plots. Revises and expands the Chapter 2 Excel Guide. Adds a Chapter 2 Tableau Guide.

**TABLE 2**  
Chapter-by-Chapter  
Change Matrix (*continued*)

Chapter	Using Statistics Changed	Problems Changed	Selected Chapter Changes
3	•	52%	Uses new samples of 479 retirement funds and 100 restaurant meal costs for in-chapter examples. Includes updated Dogs of the Dow NBA team values data sets. Adds a Chapter 3 Tableau Guide.
4	•	41%	Uses the updated Using Statistics scenario for in-chapter examples.
5		32%	Adds a new exhibit that summarizes the binomial distribution.
6		31%	Uses new samples of 479 retirement funds for the normal probability plot example.
7	•	43%	Enhances selected figures for additional clarity.
8		36%	Presents a more realistic chapter opening illustration. Revises Example 8.3 in Section 8.2 “Confidence Interval Estimate for the Mean ( $\sigma$ Unknown).”
9		29%	Adds a new exhibit that summarizes fundamental hypothesis testing concepts. Revises Section 9.2 “ <i>t</i> Test of Hypothesis for the Mean ( $\sigma$ Unknown)” example such that the normality assumption is not violated. Revises examples in Section 9.3 “One-Tail Tests” and Section 9.4 “Z Test of Hypothesis for the Proportion.”
10		37%	Uses the new tabular test summaries for the two-sample <i>t</i> test, paired <i>t</i> test, and the Z test for the difference between two proportions. Includes new Section 10.1 passage “Evaluating the Normality Assumption.” Uses new (market basket) data for the paired “ <i>t</i> test example. Enhances selected figures for additional clarity. Contains general writing improvements throughout chapter.
11	•	17%	Presents an updated chapter opening illustration. Uses revised data for the Using Statistics scenario for in-chapter examples. Uses the new tabular test summaries for the one-way ANOVA results. Presents discussion of the Levene test for the homogeneity of variance before the Tukey-Kramer multiple comparisons procedure. Revises Example 11.1 in Section 11.1 “One-Way ANOVA.”
12		37%	Uses the new tabular test summaries for the chi-square tests, Wilcoxon rank sum test, and Kruskal-Wallis rank test. Category changes in text of independence example. Uses revised data for Section 12.4 and 12.5 examples for the Wilcoxon and Kruskal-Wallis tests. Contains general writing improvements throughout chapter.

**TABLE 2**  
Chapter-by-Chapter  
Change Matrix (continued)

Chapter	Using Statistics Changed	Problems Changed	Selected Chapter Changes
13		46%	<p>Reorganizes presentation of basic regression concepts with new “Preliminary Analysis” passage and a revised Section 13.1 retitled as “Simple Linear Regression Models.”</p> <p>Revises the exhibit in Section 13.9 that summarizes avoiding potential regression pitfalls.</p> <p>Presents an updated chapter opening illustration.</p> <p>Enhances selected figures for additional clarity.</p> <p>Adds a Chapter 13 Tableau Guide.</p>
14		29%	<p>Retitles Section 14.2 as “Evaluating Multiple Regression Models.”</p> <p>Uses tables to summarize the net effects in multiple regression and residual analysis.</p> <p>Uses the new tabular test summaries for the overall <math>F</math> test, the <math>t</math> test for the slope, and logistic regression.</p> <p>Adds the new “What Is Not Normal? (Using a Categorical Dependent Variable)” <i>Consider This</i> feature.</p> <p>Adds a new section on cross-validation.</p> <p>Enhances selected figures for additional clarity.</p> <p>Contains general writing improvements throughout chapter.</p>
15		36%	<p>Uses the new tabular test summaries for the quadratic regression results.</p> <p>Revises Section 15.2 “Using Transformations in Regression Models.”</p> <p>Replaces Example 5.2 in Section 15.2 with a new sales analysis business example.</p> <p>Reorganizes Section 15.4 “Model Building.”</p> <p>Updates the Section 15.4 exhibit concerning steps for successful model building.</p> <p>Contains general writing improvements throughout chapter.</p>
16	•	67%	<p>Combines old Sections 16.1 and 16.2 into a revised Section 16.1 “Time-Series Component Factors. Section 16.1 presents a new illustration of time-series components.</p> <p>Uses updated movie attendance time-series data for the Section 16.2 example.</p> <p>Uses new annual time-series revenue data for Alphabet Inc. for Sections 16.3 and 16.5 examples.</p> <p>Uses updated annual time-series revenue data for the Coca-Cola Company in Section 16.4.</p> <p>Uses new quarterly time-series revenue data for Amazon.com, Inc. for the Section 16.6 example.</p> <p>Uses updated data for moving averages and exponential smoothing.</p> <p>Uses updated data for the online Section 16.7 “Index Numbers.”</p>
17	•	100%	<p>Completely new “Business Analytics” that expands and updates old Sections 17.3 through 17.5.</p> <p>Includes the new “What’s My Major If I Want to Be a Data Miner?” <i>Consider This</i> feature.</p>

**TABLE 2**  
Chapter-by-Chapter  
Change Matrix (*continued*)

Chapter	Using Statistics Changed	Problems Changed	Selected Chapter Changes
18		55%	Updates old Chapter 17 Sections 17.1 and 17.2 to form the new version of the “Getting Ready to Analyze Data in the Future” chapter.
Appendices		n.a.	Adds new Tableau sections to Appendices B, D, and G. Adds new Appendix B section about using non-numerical labels in time-series plots. Includes updated data files listing in Appendix C.

## Serious About Writing Improvements

Ever read a textbook preface that claims writing improvements but offers no evidence? Among the writing improvements in this edition of *Statistics for Managers Using Microsoft Excel*, the authors have used tabular summaries to guide readers to reaching conclusions and making decisions based on statistical information. The authors believe that this writing improvement, which appears in Chapters 9 through 15, adds clarity to the purpose of the statistical method being discussed and better illustrates the role of statistics in business decision-making processes.

For example, consider the following sample passage from Example 10.1 in Chapter 10 that illustrates the use of the new tabular summaries.

**Previously, part of the Example 10.1 solution was presented as:**

You do not reject the null hypothesis because  $t_{STAT} = -1.6341 > -1.7341$ . The  $p$ -value (as computed in Figure 10.5) is 0.0598. This  $p$ -value indicates that the probability that  $t_{STAT} < -1.6341$  is equal to 0.0598. In other words, if the population means are equal, the probability that the sample mean delivery time for the local pizza restaurant is at least 2.18 minutes faster than the national chain is 0.0598. Because the  $p$ -value is greater than  $\alpha = 0.05$ , there is insufficient evidence to reject the null hypothesis. Based on these results, there is insufficient evidence for the local pizza restaurant to make the advertising claim that it has a faster delivery time.

**In this edition, we present the equivalent solution (on page 316):**

Table 10.4 summarizes the results of the pooled-variance  $t$  test for the pizza delivery data using the calculation above (*not shown in this sample*) and Figure 10.5 results. Based on the conclusions, the local branch of the national chain and a local pizza restaurant have similar delivery times. Therefore, as part of the last step of the DCOVA framework, you and your friends exclude delivery time as a decision criteria when choosing from which store to order pizza.

**TABLE 10.4** Pooled-variance  $t$  test summary for the delivery times for the two pizza restaurants

Result	Conclusions
The $t_{STAT} = -1.6341$ is greater than $-1.7341$ .	<ol style="list-style-type: none"> <li>1. Do not reject the null hypothesis <math>H_0</math>.</li> <li>2. Conclude that insufficient evidence exists that the mean delivery time is lower for the local restaurant than for the branch of the national chain.</li> <li>3. There is a probability of 0.0598 that <math>t_{STAT} &lt; -1.6341</math>.</li> </ol>
The $t$ test $p$ -value = 0.0598 is greater than the level of significance, $\alpha = 0.05$ .	

## A Note of Thanks

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Please email us at [authors@davidlevinestatistics.com](mailto:authors@ davidlevinestatistics.com) with your questions about the contents of this book. Please include the hashtag #SMUME9 in the subject line of your email. We always welcome suggestions you may have for a future edition of this book. And while we have strived to make this book as error-free as possible, we also appreciate those who share with us any issues or errors that they discover.

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