


Preface

In *Business Statistics in Practice, Fourth Edition*, we provide a modern, practical, and unique framework for teaching the first course in business statistics. This framework features case study and example driven discussions of all basic business statistics topics. In addition, we have endeavored to make this book the most clearly written, motivating, and easy to use business statistics text available. We have taken great pains to explain concepts simply from first principles. Therefore, the only prerequisite for this book is high school algebra.

Business Statistics in Practice has five attributes that make it an effective learning tool:

- A consistent theme of business improvement through statistical analysis.
- A unique use of “continuing” case studies that integrates different statistical areas.
- A real emphasis on the study of variation that stresses that the analysis of individual population observations is as important as the analysis of population means.
- A flexible topic flow that facilitates different topic choices and encourages different teaching approaches. In particular, since many courses give different emphases to probability, hypothesis testing, regression and statistical modeling, nonparametric statistics, and quality control, this book provides great flexibility with respect to how, when, and whether to cover these topics.
- A modern use of the statistical capabilities of the software packages MINITAB, Excel, and MegaStat (an Excel add-in package included on the text’s student CD-ROM) that stresses statistical interpretation and that reflects the use of these packages in the real world.

New to the fourth edition are

- *The cell phone case*, which is the first continuing case in Chapter 1, discusses how a bank uses a random sample to estimate its cell phone costs. Using this estimate, the bank decide whether to outsource management of its wireless resources. This case should be particularly motivating to students because it addresses a real problem faced by both students and businesses—unpleasantly high cell phone bills.
- *Continuing cases with no need to refer back to previously given computer outputs*. Each time a continuing case is revisited, any needed computer output is included with the current case discussion. In addition, whenever possible the background information needed to understand the current analysis is provided, so the student does not need to refer back to previous material.
- *Business improvement icons*  placed in the page margins identify when an important business conclusion has been reached using statistical analysis. Each conclusion is also highlighted for additional emphasis.
- *Confidence intervals for and hypothesis tests about a population mean presented by using the σ known/ σ unknown approach*. This approach simplifies the choice of z or t -based procedures and is consistent with computerized procedures provided by MINITAB, Excel, and MegaStat. A t distribution table with up to 100 degrees of freedom is given in Table A.20 of Appendix A. Confidence intervals for and hypothesis tests about the difference between two population means are also presented using the σ known/ σ unknown approach.
- *Completely updated end of chapter computer appendices* that clearly show how to perform statistical analysis using MINITAB (Version 14), Microsoft Excel 2003, and the latest version of MegaStat.
- *Expanded coverage of sampling in Chapter 1*. We now discuss using both a random number table and computer generated random numbers to select a random sample. We also have added an optional section that introduces stratified, cluster, and systematic sampling and discusses the problems of undercoverage, nonresponse, and response bias.
- *A substantial number of new, real world data sets in the exercises*, particularly in the exercises of Chapter 1 and Chapter 2 (Descriptive Statistics).

- *An optional appendix on covariance and correlation.* This end of book appendix (Appendix B) can be covered either after covering scatter plots in Chapter 2 or before covering simple linear regression analysis in Chapter 11. Or, it can be omitted entirely without loss of continuity.
- *An optional appendix on normal probability plots.* This end of book appendix (Appendix D) supplements the normal distribution discussion in Chapter 5.
- *A simpler and easier to understand example introducing sampling distributions.* This stock return example motivates the discussion of the sampling distribution of the sample mean in Chapter 6.
- *Increased emphasis on the concept of the margin of error* to better motivate the discussion of confidence intervals in Chapter 7.
- *A step-by-step hypothesis testing approach* that is used in almost all hypothesis testing examples in Chapter 8 (Hypothesis Testing) and Chapter 9 (Statistical Inferences Based on Two Samples). This approach consists of a seven-step procedure that is designed to break hypothesis testing down into small, easy to understand steps and to also clearly show how to use the book's hypothesis testing summary boxes. Although the seven-step procedure is not formally used after Chapter 9, the students' familiarity with the steps and summary boxes should enable them to successfully carry out hypothesis tests in later chapters.
- *Increased emphasis in Chapter 9 on the "unequal variances" t-based procedure for comparing two population means.* This procedure is becoming increasingly popular because it is available in most statistical software packages and is a very accurate approximation that does not require assuming equal population variances.
- *A simplified and improved discussion of simple and multiple regression analysis.* In simple regression (Chapter 11), we give more concise explanations of the simple linear regression model, least squares, and confidence and prediction intervals. In addition to using improved graphics, the chapter provides the flexibility to cover simple coefficients of determination and correlation (Section 11.6) early or later in the chapter. In multiple regression (Chapter 12), we have refined the innovative, modular organization of the third edition. This will make it easier to selectively cover whatever multiple regression (and model building) topics are desired. We have also simplified the presentation of dummy variables and added a short section on *logistic regression*. In both the simple and multiple regression chapters, we have improved our explanations and use of MINITAB, Excel and MegaStat regression outputs. Key outputs are more clearly annotated to help the beginner find needed regression quantities.

In addition, as in the third edition, there is an optional section in Chapter 5 that covers use of the cumulative normal table. Although (because of reviewer input), we use the standard normal table to explain confidence intervals and hypothesis tests based on the normal distribution, we have explicitly designed the figures illustrating normal curve areas so that the intervals and tests can also be explained using the cumulative normal table.

We now discuss in more detail the attributes that make *Business Statistics in Practice* an effective learning tool.

Business improvement through statistical analysis The ultimate goal of statistical analysis in business is business improvement. This theme is the foundation for the case studies and examples in this text, many of which are based on actual, real world situations. For example, consider the following synopses of three case studies.

- **The Cheese Spread Case:** The marketer of a soft cheese spread wishes to replace the spout on its plastic dispenser with a less expensive spout. The company uses confidence intervals to conclude that demand for the spread will remain sufficiently high when the change is made to make replacing the spout profitable.
- **The Trash Bag Case:** A leading producer of trash bags uses hypothesis testing to convince the standards and practices division of a major television network that advertising claims about its newest trash bag are valid.
- **The Fuel Consumption Case:** A natural gas company uses regression analysis to predict its city's natural gas needs accurately enough to avoid paying fines to a pipeline transmission system.

In each of these cases, statistical analysis leads to an informed action (replace the spout, advertise the claim, use the regression prediction procedure) that results in business improvement. Furthermore, we continue this theme throughout the presentation of all statistical techniques in this book. For instance, we use descriptive and inferential statistics to compare the risk and return characteristics of different investment choices in order to improve the way we manage an investment portfolio; we use statistical process control to improve manufacturing and service processes; and we use design of experiments to study the effects of several different advertising campaigns in order to improve how a product is marketed.

A unique continuity of presentation and use of case studies *Business Statistics in Practice* features a unique continuity of presentation that integrates different statistical areas. This integration is achieved by an early emphasis (in Chapters 1 and 2) on the difference between the population and the sample and by a continuing use of practical, realistic case studies that span not only individual chapters but also groups of chapters. Specifically, Chapter 1 shows how to select random (or approximately random) samples from populations and processes by introducing four case studies as examples and by presenting additional case studies as exercises. Then in Chapter 2 we show how to use descriptive statistics to estimate the important aspects of these populations and processes. We continue to employ these case studies through the probability and sampling distribution chapters until we use confidence intervals and hypothesis testing to make statistical inferences. Furthermore, we introduce new case studies in each and every chapter. For example, we introduce several case studies in our presentation of simple linear regression and then extend these case studies when we discuss multiple regression and model building to show how regression is used in the description, prediction, and control of business variables.

A real emphasis on the importance of variation *Business Statistics in Practice* emphasizes that since businesses must satisfy individual customers, the analysis of individual population observations—which is achieved by analyzing population variation—is as important as analyzing the population mean. Our discussion of variation begins in Chapter 1, where we intuitively examine the variation of sample data and use simple runs plots to evaluate statistical control. This discussion continues in Chapter 2, where we use the empirical rule to estimate tolerance intervals containing different percentages of population observations. For example, we use the empirical rule in the

- **Payment Time Case** to describe the variation of individual bill payment times around the estimated mean bill payment time for a new electronic billing system.
- **Marketing Research Case** to describe the variation of individual customer ratings of a new soft drink bottle design around the estimated mean rating of the new design.
- **Car Mileage Case** to describe the variation of individual gas mileages around the estimated mean mileage obtained by a new midsize car.

In addition, in the **coffee temperature case** we introduce the idea of process capability—determining whether almost all process observations fall within customer requirements—and in other case studies we consider the problems involved with describing the variation of highly skewed populations.

Our emphasis on variation continues throughout the book. For example, in Chapter 7 we clearly distinguish between a confidence interval for a population mean and a tolerance interval for a given percentage of individual population measurements. In Chapter 8 we discuss the effect of variation on the interpretation of a hypothesis test about the population mean. In Chapters 11 through 13 we show how prediction intervals can be used to evaluate the predictive capabilities of different regression and time series forecasting models. In addition, we demonstrate how prediction intervals are used to assess whether any individual population observations are “unusual” enough to suggest the need for process improvement. Finally, in Chapter 14 we present a complete discussion of statistical process control and improvement (including the six sigma philosophy adopted by Motorola, Inc., and a number of other prominent U.S. companies). Furthermore, in all of these chapters we use practical case studies to illustrate the ideas being presented.

A flexible topic flow Although the table of contents of this book reveals a rather standard topic organization, the book utilizes a flexible topic flow that facilitates different topic choices and encourages different teaching approaches. In particular, since different courses place different amounts of emphasis on probability, hypothesis testing, regression and statistical modeling, nonparametric statistics, and quality control, this book provides great flexibility with respect to

how, when, and whether to cover these topics. Furthermore, in optional sections, appendices, and self-learning exercises, the book gives the student the opportunity to study more advanced topics in a concise and practical way. Thus, as we now discuss, courses with a wide variety of topic coverages and emphases can be taught using this book.

Probability The most minimal approach to probability would cover Section 3.1 (the concept of probability), Section 4.1 (random variables), Section 5.1 (continuous probability distributions), and Section 5.3 (the normal distribution, including an intuitive example of the addition rule for mutually exclusive events). These sections are the only prerequisites for Chapters 6 through 14 (sampling distributions, confidence intervals, hypothesis testing, experimental design, regression, time series forecasting, and quality control).

Instructors who wish to also cover discrete probability distributions (Chapter 4) have the option of doing this either with a fairly minimal probability background or with a complete probability background. The fairly minimal probability background consists of Section 3.1 (the concept of probability) and Section 3.2 (using sample spaces to find probabilities). Note that this background is sufficient because, since Example 4.2 of Chapter 4 intuitively illustrates the multiplication rule for independent events and the addition rule for mutually exclusive events in the context of finding a discrete probability distribution, it is not necessary to cover the complete discussion of probability rules given in Sections 3.3 and 3.4. Of course, this complete discussion is necessary background for covering chi-square tests of independence (Chapter 16) and Bayes' Theorem and decision theory (Chapter 17). Also, the complete discussion features the **AccuRatings Case**, which is a very motivating data driven application of the probability rules.

Hypothesis testing In the fourth edition we have used a seven-step procedure to break hypothesis testing down into small, easy-to-understand steps and to clearly show how to use the book's hypothesis testing summary boxes. In addition, we have fully and concisely integrated the discussion of using rejection points and p -values. The seven-step procedure shows how to use both approaches, and the hypothesis testing boxes summarize both rejection points and p -values for each test. We have also motivated the link between the approaches by considering how major television networks sometimes use different α values when evaluating advertising claims. We are aware of several courses that introduce hypothesis testing in the context of using p -values to test the significance of regression coefficients. This can be done in our book by totally skipping Chapter 8 and by noting that every section throughout the rest of the book includes self-contained summary boxes (and examples) that fully cover any needed confidence intervals and hypothesis tests. Also, Chapter 6 (sampling distributions) intuitively illustrates the use of p -values in the context of evaluating a claim about a population mean and in the context of evaluating a claim about a population proportion. Therefore, Chapter 6 can be used as an extremely short, intuitive introduction to p -values.

Regression and statistical modeling The fourth edition features an innovative organization of regression analysis that simplifies the flow of the overall discussion and makes it very easy to cover whatever regression topics are desired. As in the third edition, we have included an optional section on residual analysis at the end of the simple linear regression chapter (Chapter 11). In Chapter 12: Multiple Regression and Model Building, we have refined the modular organization of the third edition and have made it easier to cover whatever portions of multiple regression and model building are desired. As shown in a diagram on its opening page, Chapter 12, consists of four parts. Part 1: Basic Multiple Regression discusses the basic descriptive and inferential techniques of multiple regression analysis and would be a sufficient introduction to this topic for many introductory business statistics courses. After completing Part 1, the reader can study optional Part 2: Using Squared and Interaction Terms, optional Part 3: Dummy Variables and Advanced Statistical Inferences, and any section of optional Part 4: Model Building and Model Diagnostics. These optional parts can be covered in any order and without loss of continuity (note that Part 4 consists of four self-contained sections: model building and the effects of multicollinearity; residual analysis in multiple regression; diagnostics for detecting outlying and influential observations; and logistic regression). Furthermore, material covering model diagnostics and topics in some of the supplementary exercises, tie key portions of the four parts together. This approach allows instructors to easily cover what they consider most important in courses with limited time devoted to regression analysis. Similarly, since many business statistics courses do not have substantial time to devote to experimental design (Chapter 10) and time series forecasting (Chapter 13), we have put great effort into making our presentation of these topics both complete and easy to get through.

Nonparametric statistics We have placed all of the nonparametric techniques covered in the book in Chapter 15. Furthermore, at the end of the discussion of each parametric technique in Chapters 8 through 11 we refer readers to the section in Chapter 15 that discusses the nonparametric technique that would be used if the assumptions for the parametric technique fail to hold. Therefore, the instructor has the option of integrating the discussion of nonparametric statistics into the main flow of Chapters 8 through 11.

Quality control Process improvement through control charts is discussed in Chapter 14. Thus, this topic is placed outside of the main flow of what might be regarded as classical statistics. However, since Chapter 14 has as its only prerequisite Chapter 6 on sampling distributions, the instructor has the option to cover Chapter 14 at any point after Chapter 6.

Optional Advanced Topics In optional sections, appendices, and self-learning exercises, the book gives the student the opportunity to study more advanced topics in a concise and practical way. Examination of the table of contents reveals that many of the more advanced topics—for example, counting rules (Appendix B, Part 1), the hypergeometric distribution (Appendix B, Part 2), covariance and correlation (Appendix C), normal probability plots (Appendix D), the Poisson and exponential distributions (Sections 4.4 and 5.5), calculating the probability of a Type II error (Section 8.6), and statistical inferences for a population variance (Section 8.8)—are included in many other business statistics books. However, some of the more advanced topics, while not unique to this book, are less frequently covered in other basic statistics texts. These topics (the most advanced of which are discussed in CD-ROM Appendices E through L) are as follows:

- Properties of the Mean and Variance of a Random Variable, and the Covariance Between Two Random Variables (Appendix E, Part 1).
- Derivations of the Mean and the Variance of the Sample Mean and of the Mean and the Variance of the Sample Proportion (Appendix E, Part 2).
- Confidence Intervals for Parameters of Finite Populations (Section 7.5), including sample size determination (Exercise 7.57).
- An Introduction to Survey Sampling (Section 1.5); estimation formulas, optimal allocation, and sample size determination in stratified random sampling (Appendix F, Part 1); and estimation formulas in one- and two-stage cluster sampling and ratio estimation (Appendix F, Part 2).
- A Comparison of Confidence Intervals and Tolerance Intervals (Section 7.6).
- Using Matrix Algebra to Perform Regression Calculations (Appendix G).
- The regression approach to one-way analysis of variance (Exercise 12.45), and the regression approach to two-way analysis of variance (Appendix H).
- Advanced Model Diagnostics (Exercises 12.76 and 12.77) and Model Building with Squared and Interaction Terms (Exercise 12.74).
- Logistic Regression (Section 12.15) and Discriminant Analysis (Exercise 12.78).
- Factor Analysis, Cluster Analysis, and Multidimensional Scaling (Appendix I).
- Double Exponential Smoothing and Winters' Method (an intuitive discussion in Section 13.5 and a detailed discussion in Appendix K).
- The Box–Jenkins methodology, a fairly complete discussion featuring nonseasonal and seasonal modeling, using autocorrelated error term models in regression analysis, intervention analysis, and transfer function models (Appendix J).
- Individuals charts and c charts (Appendix L).

Furthermore, we have put great effort into making the discussion of all of the more advanced topics clear, concise, and easy to get through. This gives the instructor considerable flexibility in designing different business statistics courses. For example, a professor teaching a second course in business statistics can opt to either cover a variety of intermediate topics or present a more in-depth treatment of regression analysis and forecasting.

MINITAB, Excel, and MegaStat *Business Statistics in Practice, Fourth Edition*, features a modern use of the statistical capabilities of the software packages MINITAB, Excel, and the Excel add-in MegaStat. Throughout the book we provide an abundant number of outputs from all three packages in both examples and exercises that allow students to concentrate on statistical

interpretations. This use of outputs is particularly prominent in statistical areas where hand calculations are impossible or impractical and where having students run their own programs (while theoretically optimal) would, because of time constraints, not allow them to see a wide variety of applications. These areas include descriptive statistics, ANOVA, regression, and time series forecasting. In addition, appendices at the end of each chapter show in detail how to use MINITAB, Excel, and MegaStat to implement the statistical techniques discussed in the chapter. For the fourth edition, the developer of MegaStat, Professor J. B. Orris of Butler University, has worked closely with us. We believe that MegaStat is the most comprehensive, accurate, and easy to use Excel add-in package in existence. In addition to remedying most of the computational problems associated with Excel Data Analysis Tools, MegaStat is also specifically designed to enhance the use of *Business Statistics in Practice*. For example,

- In addition to giving the usual descriptive statistics, frequency distributions, and histograms, MegaStat provides stem-and-leaf displays, box plots, dot plots, runs plots, normal plots, and output for the Empirical Rule (as well as tolerance intervals estimated to contain any specified percentage of individual observations). MegaStat also gives the option to calculate tolerance intervals and confidence intervals using the same dialog box. Therefore, students can better understand the crucial difference between these two types of intervals (as illustrated on pages 000 and 000).
- The MegaStat dialog box for every one and two sample hypothesis testing procedure for means and proportions allows the user to calculate a confidence interval for the population parameter being tested. Therefore, the student is encouraged to evaluate both statistical significance and practical importance. Such evaluation is a consistent theme of *Business Statistics in Practice* (in particular, see Chapters 8 and 9).
- MegaStat's one-way ANOVA, randomized block, and two-factor ANOVA procedures provide graphical output helping students to better analyze experimental data. In addition, each procedure provides easy to understand pairwise comparisons of population means using both Tukey procedures and individual *t*-tests. Such graphical analysis and pairwise comparisons are emphasized in Chapter 10.
- In addition to providing confidence intervals and prediction intervals in simple and multiple regression, MegaStat gives a full range of residual plots, normal plots, and outlying and influential observation diagnostics, as well as the variance inflation factors for the independent variables in a regression model. In addition, MegaStat provides an all possible regressions output that summarizes all well known model selection criteria, as well as the *p*-values for the independent variables. MegaStat also gives a stepwise selection procedure that provides more information than given by classical stepwise regression or backward elimination. MegaStat's regression capabilities are designed to enhance the regression coverage in Chapters 11 and 12. Furthermore, all of MegaStat's regression capabilities can be accessed in one very easy to use dialog box, allowing the student to carry out a wide range of regression procedures in a correct, informative, and simple way.

In addition, MegaStat is fully capable of performing analysis related to discrete and continuous probability distributions, time series forecasting, nonparametric statistics, chi-square tests, and statistical quality control charts—virtually all topics covered by *Business Statistics in Practice*. MegaStat is provided on the student CD-ROM.

Further Features The book's CD-ROM, in addition to containing the previously discussed advanced topic appendices and MegaStat, also features Excel templates, data files, tutorials, web links, self quizzes, PowerPoint presentations, and Visual Statistics 2.0 by Doane, Mathieson, and Tracy. Visual Statistics is a Windows software program that helps students learn statistics through interactive experimentation and visualization. Visual statistics icons in the text identify concepts that are further explained by Visual Statistics. This edition also features Homework Manager. This is an online electronic tutor customized to the text and available as an option to students.

In addition, the book has the following supplements: an instructor's solutions manual developed by Patrick Schur, Miami University, and test bank developed by Denise Krallman, Miami University (included on the instructor's edition CD-ROM and available in print format); a student study guide developed by Sandra Strassar, Valparaiso University (available in print format); and PowerPoint transparency masters developed by Ronny Richardson, Southern Polytechnic State University, with contributions by Harvey Singer, George Mason University.

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