PRACTICAL BUSINESS STATISTICS

FOURTH EDITION

ANDREW F. SIEGEL

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Practical Business Statistics

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PRACTICAL BUSINESS STATISTICS
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PREFACE

The traditional business statistics course has changed, and mainly for the better: more interpretation of results, more emphasis on concepts and ideas, more integration of statistical thinking with other business activities, all while solidifying the understanding of fundamental statistical principles. *Practical Business Statistics* has been a leader in this change. The preface of the first three editions included these words:

> The traditional business statistics course is changing. Now that computers are so widely available for number crunching, many old-fashioned topics are no longer worth covering in complete detail. This creates a tremendous opportunity for using new material during class time that will be more useful to a business manager—new material that solidifies the *concepts* and the *applications* of statistics to business and economics. For example, managers do not need to know how to derive the formulas for the least-squares regression coefficients, but they need to know how to interpret these regression coefficients so that appropriate decisions can be made based on these important summaries of relationships in complex situations.
>
> *Practical Business Statistics* was written with this change in mind. Business students can excel at statistics when they are motivated by real-world examples and clear, direct explanations that show them why it is worthwhile to learn the statistical view of the world. Business students are different from other students and deserve a book created especially for their needs and interests.

Extensive Development: Reviews and Class Testing

This project began as a collection of readings I handed out to my students as a supplement to the assigned textbook. All of the available books seemed to make statistics seem unnecessarily difficult, and I wanted to present the straightforward, easy ways to think about the subject. I also wanted to add more of a modern, real-world business flavor to the topic. All of the helpful feedback I have received from students over the years has been acted upon and has improved the book.

Even before the first edition was published, *Practical Business Statistics* went through several stages of reviewing and classroom testing. Now that three editions have been used in colleges and universities across the country and around the world, preparing the fourth edition has given me the chance to fine-tune the book, based on the additional reviews and all the helpful, encouraging comments that I have received.

Writing Style

I enjoyed writing this book. I have presented the "inside scoop" wherever possible, explaining how we statisticians *really* think about a topic, what it implies, and how it is useful. This approach helps bring some sorely needed life to a subject that unfortunately suffers from dreadful public relations. Of course, the traditional explanations are also given here so that you can see it both ways: here is what we say, and here is what it means.

It thrilled me to hear even some of my more quantitative-phobic students tell me that the text is actually *enjoyable to read!* And this was *after* the final grades were in!

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Examples

Examples bring statistics to life, making each topic relevant and useful. There are many real-world examples used throughout *Practical Business Statistics,* chosen from a wide variety of business sources. The stock market is used in Chapter 5 to illustrate market volatility and risk as measured by the standard deviation. Quality control is used throughout the book to illustrate individual topics and is also covered in its own chapter (18). Opinion surveys and election polls are used throughout the book (and especially in Chapter 9) because they represent a very pure kind of real-life statistical inference that we are all familiar with. Using the Internet to locate data is now featured in Chapter 2. Prices of magazine advertisements are used in Chapter 12 to show how multiple regression can uncover relationships in complex data sets. Unemployment rates are used in Chapter 14 to demonstrate what goes on behind the scenes in time-series forecasting. Students learn better through the use of motivating examples and applications.

Statistical Graphics

To help show what is going on in the data sets, *Practical Business Statistics* includes over 200 figures to illustrate important features and relationships. The graphs are exact because they were initially drawn with the help of a computer. For example, the bell-shaped normal curves here are accurate, unlike those in many books, which are distorted because they appear to be an artist's enhancement of a casual, hand-drawn sketch. There is no substitute for accuracy! This helps the student grasp the concepts more clearly.

Cases

To show how statistical thinking can be useful as an integrated part of a larger business activity, cases are included at the end of each of Chapters 3–12. These cases provide extended and open-ended situations as an opportunity for thought and discussion, often with no single correct answer.

What's New in the Fourth Edition

Here is a summary of the main changes. Many of the examples and problems in the fourth edition have been brought up to date with more recent data sets. Excel® screen shots are now included throughout the book to illustrate how to perform many operations directly in a spreadsheet. Coverage of sources of data has been increased in Chapter 2, featuring the Internet as a resource. The Internet is also often suggested as a method for locating data to use with end-of-chapter projects. A logo is placed next to Internet problems or data sources. While making these changes, I've done my best to retain the features that have worked well for students and instructors in the first three editions.

Organization

A student should always know *why* the current material is important. For this reason, each part begins with a brief look at the subject of that part and the chapters to come. Each chapter begins with an overview of its topic, showing why the subject is important to business, before proceeding to the details and examples.

Key words, the most important terms and phrases, are presented in bold in the sentence of the text where they are defined. They are collected in the Key Words list at the end of each chapter and also included in the glossary at the back of the book. This makes

it easy to study by focusing attention on the main ideas. An extensive index helps you find main topics as well as small details. Try looking up "examples," "correlation," "unpaired *t* test," or even "microprocessor."

Extensive end-of-chapter materials are included, beginning with a *summary* of the important material covered. Next is the list of *key words*. The *questions* provide a review of the main topics, indicating why they are important. The *problems* give the student a chance to apply statistics to new situations. The *database exercises* (included in most chapters) give further practice problems based on the employee database in Appendix A. The *projects* bring statistics closer to the students' needs and interests by allowing them to help define the problem and choose the data set from their work experience or interests from sources including the Internet, current publications, or their company. Finally, the *cases* (one each for Chapters 3–12) provide extended and open-ended situations as an opportunity for thought and discussion, often with no single correct answer.

Several relatively new topics are covered in addition to the foundations of statistics and their applications to business. Because communication is so important in the business world, Chapter 13 shows how to gather and present statistical material in a report. Chapter 14 includes an intuitive discussion of the Box-Jenkins forecasting approach to time series using ARIMA models. Chapter 18 shows how statistical methods can help you achieve and improve quality; discussion of quality control techniques is also interspersed throughout the text.

Practical Business Statistics is organized into five parts, plus appendices, as follows:

Part I, Chapters 1 through 5, is "Introduction and Descriptive Statistics." Chapter 1 motivates the student by showing how the use of statistics provides a competitive edge in business. Chapter 2 surveys the various types of data sets (quantitative, qualitative, ordinal, nominal, bivariate, time-series, etc.), the distinction between primary and secondary data, and use of the Internet. Chapter 3 shows how the histogram lets you see what's in the data set, which may be difficult to determine just from staring at a list of numbers. Chapter 4 covers the basic landmark summaries, including the average, median, mode, and percentiles, which are displayed in box plots and cumulative distribution functions. Chapter 5 discusses variability, which often translates to *risk* in business terms, featuring the standard deviation as well as the range and coefficient of variation.

Part II, including Chapters 6 and 7, is "Probability." Chapter 6 covers probabilities of events and their combinations, using probability trees both as a way of visualizing the situation and as a way of computing probabilities. Conditional probabilities are interpreted as a way of making the best use of the information you have. Chapter 7 covers random variables (numerical outcomes), which often represent those numbers that are important to your business but are not yet available. Details are provided concerning general discrete distributions, the binomial distribution, the normal distribution, and (briefly) the Poisson and exponential distributions.

Part III, Chapters 8 through 10, is "Statistical Inference." These chapters pull together the descriptive summaries of Part I and the formal probability assessments of Part II. Chapter 8 covers random sampling, which forms the basis for the exact probability statements of statistical inference and introduces the central limit theorem and the all-important notion of the standard error of a statistic. Chapter 9 shows how confidence intervals lead to an exact probability statement about an unknown quantity based on statistical data. Both two-sided and one-sided confidence intervals are covered, in addition to prediction intervals for a new observation. Chapter 10 covers hypothesis testing, often from the point of view of distinguishing the presence of a real pattern from mere random coincidence. By building on the intuitive process of constructing confidence intervals from

Chapter 9, hypothesis testing can be performed in a relatively painless intuitive manner while ensuring strict statistical correctness.

Part IV, Chapters 11 through 14, is "Regression and Time Series." These chapters apply the concepts and methods of the previous parts to more complex and more realistic situations. Chapter 11 shows how relationships can be studied and predictions can be made using correlation and regression methods on bivariate data. Chapter 12 extends these ideas to multiple regression, perhaps the most important method in statistics, with careful attention to interpretation, diagnostics, and the idea of "controlling for" or "adjusting for" some factors while measuring the effects of other factors. Chapter 13 provides a guide to report writing to help the student communicate the results of a multiple regression analysis to other business people. Chapter 14 introduces the new and different methods that are required for time-series analysis. The trend-seasonal approach is used to give an intuitive feeling for the basic features of a time series. Box-Jenkins methods are covered to show how these complex, modern methods can handle more difficult situations.

Part V, Chapters 15 through 18, is "Methods and Applications," a grab bag of optional, special topics that extend the basic material covered so far. Chapter 15 shows how the analysis of variance allows us to use hypothesis testing in more complex situations. Chapter 16 covers nonparametric methods, which can be used when the basic assumptions for hypothesis testing are not satisfied, that is, for cases where the distributions might not be normal or the data set might be merely ordinal. Chapter 17 shows how chi-squared analysis can be used to test relationships among the categories of nominal data. Finally, Chapter 18 shows how quality control relies heavily on statistical methods such as Pareto diagrams and control charts.

Appendix A is the "Employee Database," consisting of information on salary, experience, age, gender, and training level for a number of administrative employees. This data set is used in the *database exercises* section at the end of most chapters. Appendix B gives detailed solutions to selected parts of problems and database exercises (marked with a logo in the text). Appendix C collects all of the statistical tables used throughout the text. Appendix D provides a quick reference guide to StatPad, an Excel® add-in.

Excel® Guide

The Excel® Guide, prepared by Andrew F. Siegel, provides examples of statistical analysis using Excel® using data taken chapter-by-chapter from *Practical Business Statistics*. It's a convenient way for your students to learn how to use computers if you have chosen to use Excel®. It is included on the CD-ROM in this text.

StatPad Optional Software

StatPad is an add-in that simplifies analysis when using Excel® and is included on the CD-ROM with this text. Statistical methods are organized for quick and easy access, and results are placed back into the worksheet together with an explanation of the results. In addition to making computation more accessible, this approach ensures that the students will still have convenient access to statistical methods after the course is over, and even after graduation! You will find a quick overview of StatPad's capabilities in Appendix D.

StatPad was developed by Skyline Technologies, Inc., with the assistance of Andrew F. Siegel. Through the use of familiar Windows® and Excel® style dialog boxes, with the results placed back into the spreadsheet, statistics operations essentially become part of the worksheet, just like any other spreadsheet command. By breaking down barriers to the effective use of computers, statistical concepts can be learned more quickly and painlessly!

Instructor's Manual

The instructor's manual (ISBN 0-07-233611-0) is designed to help save time in preparing lectures. A brief discussion of teaching objectives and how to motivate students is provided for each chapter. Also included are detailed solutions to questions, problems, and database exercises, as well as analysis and discussion material for each case.

Test Bank

Prepared by Ted Tsukahara, the test bank (ISBN 0-07-233612-9) contains over 800 questions and problems. The questions are graded by level of difficulty and referenced to specific chapter sections. The test bank is also available on Diploma, which is a computerized test generator that allows you to access and select any of the test items in the test bank in Windows (ISBN 0-07-233615-3).

Acknowledgments

Many thanks to all of the reviewers and students who have read and commented on drafts and previous editions of *Practical Business Statistics*. I was lucky to have dedicated, careful readers at a variety of institutions who were not afraid to say what it would take to meet their needs.

I am fortunate (and proud) to have been able to keep in touch with my parents, Mildred and Armand Siegel, who provided many careful and detailed suggestions for the text.

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Thank goodness I had editors like Scott Isenberg, Gail Korosa (developmental editor), and Denise Santor-Mitzit (project editor) to watch over this project. The help of editors Richard T. Hercher, Carol Rose, Ann Granacki, Colleen Tuscher, and Margaret Haywood for earlier editions is still very much appreciated. It's a big job producing a work like this, and I was lucky to have people with so much knowledge, dedication, and organizational skill.

The creative design of the text is due to Cynthia Crampton. She was able to come up with an aesthetically pleasing layout that invites you into the book and makes it easy to locate the material you need. Mary Christianson directed the art and design programs, ensuring that the various style elements came together to form an attractive as well as functional book.

Additional thanks for helpful comments go to Ted Tsukahara, who checked the accuracy of the text and instructor's manual. Also, David Auer who prepared the practice quizzes on the student CD-ROM, and Eric Russell, Dayton Robinson, Eric J. Bean, Michael R. Fancher, Susan Stapleton, Sara S. Hemphill, Nancy J. Silberg, A. Ronald Hauver, Hirokuni Tamura, John Chiu, June Morita, Brian McMullen, David B. Foster, Pablo Ferrero, Rolf R. Anderson, Gordon Klug, Reed Hunt, E. N. Funk, Rob Gullette, David Hartnett, Mickey Lass, Judyann Morgan, Kimberly V. Orchard, Richard Richings, Mark Roellig, Scott H. Pattison, Thomas J. Virgin, Carl Stork, Gerald Bernstein, and Jeremiah J. Sullivan.

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To the Student

As you begin this course, you may have some preconceived notions of what statistics is all about. If you have positive notions, please keep them and share them with your classmates. But if you have negative notions, please set them aside and remain open-minded. Because this subject has often not been taught routinely in grade schools in many countries, relatively few university students have developed a statistical view of the world, a view that helps to deal with mountains of data when decisions must be made in the face of uncertainty.

In some ways, statistics is easier for your generation than for those of the past. Now that computers can do the messy numerical work, you are free to develop a deeper understanding of the concepts and how they can help you beat out the competition in your business career.

Make good use of the introductory material so that you will always know why statistics is worth the effort. Take advantage of the summary, key words, and other materials at the ends of the chapters. Don't forget about the detailed problem solutions and the glossary at the back when you need a quick reminder. And don't worry. Once you realize how much statistics can help you in business, the things you need to learn will fall into place much more easily.

Keep this book as a reference. You'll be glad you did when the Boss needs a memo drafted immediately that requires a quick look at some data or a response to an adversary's analysis. With the help of *Practical Business Statistics* on your bookshelf, you'll be able to finish early and still go out to dinner. *Bon appétit!*

ANDREW F. SIEGEL

ABOUT THE AUTHOR

Andrew F. Siegel is Professor, Departments of Management Science and Finance, School of Business, University of Washington, Seattle. He is also Adjunct Professor in the Department of Statistics and in the Department of Molecular Biotechnology. He has a Ph.D. in statistics from Stanford University (1977), an M.S. in mathematics from Stanford University (1975), and a B.A. in mathematics and physics summa cum laude with distinction from Boston University (1973). Before settling in Seattle, he held teaching and/or research positions at Harvard University, the University of Wisconsin, the RAND Corporation, the Smithsonian Institution, and Princeton University. He also lectures from time to time as a visiting professor at the University of Burgundy at Dijon, France, and at the Sorbonne in Paris. The very first time he taught statistics in a business school (University of Washington, 1983) he was granted the Professor of the Quarter award by the MBA students. He was named the Grant I. Butterbaugh Professor beginning in 1993; this endowed professorship was created by a highly successful executive in honor of Professor Butterbaugh, a business statistics teacher. (Students: Perhaps you will feel this way about your teacher 20 years from now.) Other honors and awards include Burlington Northern Foundation Faculty Achievement Awards, 1986 and 1992; Research Associate, Center for the Study of Futures Markets, Columbia University, 1988; Excellence in Teaching Awards, Executive MBA Program, University of Washington, 1986 and 1988; Research Opportunities in Auditing Award, Peat Marwick Foundation, 1987; and Phi Beta Kappa, 1973.

He belongs to the American Statistical Association, where he has served as Secretary-Treasurer of the Section on Business and Economic Statistics. He has written three other books: *Statistics and Data Analysis: An Introduction* (Second Edition, Wiley, 1996, with Charles J. Morgan), *Counterexamples in Probability and Statistics* (Wadsworth, 1986, with Joseph P. Romano), and *Modern Data Analysis* (Academic Press, 1982, co-edited with Robert L. Launer). His articles have appeared in many publications, including the *Journal of the American Statistical Association*, the *Journal of Business*, *Management Science*, the *Journal of Finance*, the *Encyclopedia of Statistical Sciences*, the *American Statistician*, the *Journal of Financial and Quantitative Analysis*, the *American Mathematical Monthly*, the *Journal of the Royal Statistical Society*, the *Annals of Statistics*, the *Annals of Probability*, the *Society for Industrial and Applied Mathematics Journal on Scientific and Statistical Computing*, the *Journal of Computational Biology*, *Genome Research*, *Biometrika*, *Auditing: A Journal of Practice and Theory*, *Contemporary Accounting Research*, the *Journal of Futures Markets*, and the *Journal of Applied Probability*. He has consulted in a variety of business areas, including election predictions for a major television network, statistical algorithms in speech recognition for a prominent research laboratory, television advertisement testing for an active marketing firm, quality control techniques for a supplier to a large manufacturing company, biotechnology process feasibility and efficiency for a large-scale laboratory, electronics design automation for a Silicon Valley startup and portfolio diversification analysis for a fund management company.

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