METRIC VERSION

Anderson Sweeney Williams Camm Cochran Fry Ohlmann

Statistics for Business & Economics

Metric Version · 14th Edition

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14e Metric Version

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Brief Contents

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About the Authors

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At the University of Cincinnati, Professor Anderson has taught introductory statistics for business students as well as graduate-level courses in regression analysis, multivariate analysis, and management science. He has also taught statistical courses at the Department of Labor in Washington, D.C. He has been honored with nominations and awards for excellence in teaching and excellence in service to student organizations.

Professor Anderson has coauthored 10 textbooks in the areas of statistics, management science, linear programming, and production and operations management. He is an active consultant in the field of sampling and statistical methods.

Dennis J. Sweeney. Dennis J. Sweeney is Professor Emeritus of Quantitative Analysis and Founder of the Center for Productivity Improvement at the University of Cincinnati. Born in Des Moines, Iowa, he earned a B.S.B.A. degree from Drake University and his M.B.A. and D.B.A. degrees from Indiana University, where he was an NDEA Fellow. Professor Sweeney has worked in the management science group at Procter & Gamble and spent a year as a visiting professor at Duke University. Professor Sweeney served as Head of the Department of Quantitative Analysis and as Associate Dean of the College of Business Administration at the University of Cincinnati.

Professor Sweeney has published more than 30 articles and monographs in the area of management science and statistics. The National Science Foundation, IBM, Procter & Gamble, Federated Department Stores, Kroger, and Cincinnati Gas & Electric have funded his research, which has been published in *Management Science, Operations Research, Mathematical Programming, Decision Sciences,* and other journals.

Professor Sweeney has coauthored 10 textbooks in the areas of statistics, management science, linear programming, and production and operations management.

Thomas A. Williams. Thomas A. Williams is Professor Emeritus of Management Science in the College of Business at Rochester Institute of Technology. Born in Elmira, New York, he earned his B.S. degree at Clarkson University. He did his graduate work at Rensselaer Polytechnic Institute, where he received his M.S. and Ph.D. degrees.

Before joining the College of Business at RIT, Professor Williams served for seven years as a faculty member in the College of Business Administration at the University of Cincinnati, where he developed the undergraduate program in Information Systems and then served as its coordinator. At RIT he was the first chairman of the Decision Sciences Department. He teaches courses in management science and statistics, as well as graduate courses in regression and decision analysis.

Professor Williams is the coauthor of 11 textbooks in the areas of management science, statistics, production and operations management, and mathematics. He has been a consultant for numerous *Fortune* 500 companies and has worked on projects ranging from the use of data analysis to the development of large-scale regression models.

Jeffrey D. Camm. Jeffrey D. Camm is the Inmar Presidential Chair and Associate Dean of Analytics in the School of Business at Wake Forest University. Born in Cincinnati, Ohio, he holds a B.S. from Xavier University (Ohio) and a Ph.D. from Clemson University. Prior to

joining the faculty at Wake Forest, he was on the faculty of the University of Cincinnati. He has also been a visiting scholar at Stanford University and a visiting professor of business administration at the Tuck School of Business at Dartmouth College.

Dr. Camm has published over 40 papers in the general area of optimization applied to problems in operations management and marketing. He has published his research in *Science, Management Science, Operations Research, Interfaces,* and other professional journals. Dr. Camm was named the Dornoff Fellow of Teaching Excellence at the University of Cincinnati and he was the 2006 recipient of the INFORMS Prize for the Teaching of Operations Research Practice. A firm believer in practicing what he preaches, he has served as an operations research consultant to numerous companies and government agencies. From 2005 to 2010 he served as editor-in-chief of *Interfaces.* In 2017, he was named an INFORMS Fellow.

James J. Cochran. James J. Cochran is Professor of Applied Statistics and the Rogers-Spivey Faculty Fellow at the University of Alabama. Born in Dayton, Ohio, he earned his B.S., M.S., and M.B.A. degrees from Wright State University and a Ph.D. from the University of Cincinnati. He has been at the University of Alabama since 2014 and has been a visiting scholar at Stanford University, Universidad de Talca, the University of South Africa, and Pole Universitaire Leonard de Vinci.

Professor Cochran has published over 40 papers in the development and application of operations research and statistical methods. He has published his research *in Management Science, The American Statistician, Communications in Statistics—Theory and Methods, Annals of operations Research, European Journal of Operational Research, Journal of Combinatorial Optimization. Interfaces, Statistics and Probability Letters,* and other professional journals. He was the 2008 recipient of the INFORMS Prize for the Teaching of Operations Research Practice and the 2010 recipient of the Mu Sigma Rho Statistical Education Award. Professor Cochran was elected to the International Statistics Institute in 2005 and named a Fellow of the American Statistical Association in 2011. He received the Founders Award in 2014 and the Karl E. Peace Award in 2015 from the American Statistical Association. In 2017 he received the American Statistical Association's Waller Distinguished Teaching Career Award and was named a Fellow of INFORMS, and in 2018 he received the INFORMS President's Award.

A strong advocate for effective statistics and operations research education as a means of improving the quality of applications to real problems, Professor Cochran has organized and chaired teaching effectiveness workshops in Montevideo, Uruguay; Cape Town, South Africa; Cartagena, Colombia; Jaipur, India; Buenos Aires, Argentina; Nairobi, Kenya; Buea, Cameroon; Kathmandu, Nepal; Osijek, Croatia; Havana, Cuba; Ulaanbaatar, Mongolia; and Chişinău, Moldova. He has served as an operations research consultant to numerous companies and not-for-profit organizations. He served as editor-in-chief of *INFORMS Transactions on Education* from 2006 to 2012 and is on the editorial board of *Interfaces, International Transactions in Operational Research, and Significance.*

Michael J. Fry. Michael J. Fry is Professor of Operations, Business Analytics, and Information Systems and Academic Director of the Center for Business Analytics in the Carl H. Lindner College of Business at the University of Cincinnati. Born in Killeen, Texas, he earned a BS from Texas A&M University and M.S.E. and Ph.D. degrees from the University of Michigan. He has been at the University of Cincinnati since 2002, where he was previously Department Head and has been named a Lindner Research Fellow. He has also been a visiting professor at the Samuel Curtis Johnson Graduate School of Management at Cornell University and the Sauder School of Business at the University of British Columbia.

Professor Fry has published more than 25 research papers in journals such as *Operations Research, M&SOM*, *Transportation Science, Naval Research Logistics, IIE Transactions, Critical Care Medicine* and *Interfaces*. His research interests are in applying quantitative

management methods to the areas of supply chain analytics, sports analytics, and public-policy operations. He has worked with many different organizations for his research, including Dell, Inc., Starbucks Coffee Company, Great American Insurance Group, the Cincinnati Fire Department, the State of Ohio Election Commission, the Cincinnati Bengals, and the Cincinnati Zoo & Botanical Garden. He was named a finalist for the Daniel H. Wagner Prize for Excellence in Operations Research Practice, and he has been recognized for both his research and teaching excellence at the University of Cincinnati.

Jeffrey W. Ohlmann. Jeffrey W. Ohlmann is Associate Professor of Management Sciences and Huneke Research Fellow in the Tippie College of Business at the University of Iowa. Born in Valentine, Nebraska, he earned a B.S. from the University of Nebraska, and MS and Ph.D. degrees from the University of Michigan. He has been at the University of Iowa since 2003.

Professor Ohlmann's research on the modeling and solution of decision-making problems has produced more than 20 research papers in journals such as *Operations Research, Mathematics of Operations Research, INFORMS Journal on Computing, Transportation Science,* the *European Journal of Operational Research,* and *Interfaces*. He has collaborated with companies such as Transfreight, LeanCor, Cargill, the Hamilton County Board of Elections, and three National Football League franchises. Because of the relevance of his work to industry, he was bestowed the George B. Dantzig Dissertation Award and was recognized as a finalist for the Daniel H. Wagner Prize for Excellence in Operations Research Practice.

Preface

This text is the 14th edition of *STATISTICS FOR BUSINESS AND ECONOMICS, Metric Version.* In this edition, we include procedures for statistical analysis using Excel 2016 and JMP Student Edition 14. In MindTap Reader, we also include instructions for using the exceptionally popular open-source language R to perform statistical analysis. We are excited to introduce two new coauthors, Michael J. Fry of the University of Cincinnati and Jeffrey W. Ohlmann of the University of Iowa. Both are accomplished teachers and researchers. More details on their backgrounds may be found in the About the Authors section.

The remainder of this preface describes the authors' objectives in writing *STATISTICS FOR BUSINESS AND ECONOMICS* and the major changes that were made in developing the 14th edition. The purpose of the text is to give students, primarily those in the fields of business administration and economics, a conceptual introduction to the field of statistics and its many applications. The text is applications-oriented and written with the needs of the nonmathematician in mind; the mathematical prerequisite is understanding of algebra.

Applications of data analysis and statistical methodology are an integral part of the organization and presentation of the text material. The discussion and development of each technique is presented in an application setting, with the statistical results providing insights to decisions and solutions to problems.

Although the book is applications oriented, we have taken care to provide sound methodological development and to use notation that is generally accepted for the topic being covered. Hence, students will find that this text provides good preparation for the study of more advanced statistical material. A bibliography to guide further study is included as an appendix.

The text introduces the student to the software packages of JMP Student Edition 14e and Microsoft® Office Excel 2016 and emphasizes the role of computer software in the application of statistical analysis. JMP is illustrated as it is one of the leading statistical software packages for both education and statistical practice. Excel is not a statistical software package, but the wide availability and use of Excel make it important for students to understand the statistical capabilities of this package. JMP and Excel procedures are provided in appendices so that instructors have the flexibility of using as much computer emphasis as desired for the course. MindTap Reader includes appendices for using R for statistical analysis. R is an open-source programming language that is widely used in practice to perform statistical analysis. The use of R typically requires more training than the use of software such as JMP or Excel, but the software is extremely powerful. To ease students' introduction to the R language, we also use RStudio which provides an integrated development environment for R.

This international metric version is designed for classrooms and students outside of the United States. The units of measurement used in selected examples and exercises have been changed from U.S. Customary units to metric units.

Changes in the 14th Edition

We appreciate the acceptance and positive response to the previous editions of *Statistics for Business and Economics.* Accordingly, in making modifications for this new edition, we have maintained the presentation style and readability of those editions. There have been many changes made throughout the text to enhance its educational effectiveness. The most substantial changes in the new edition are summarized here.

Content Revisions

- **Software.** In addition to step-by-step instructions in the software appendices for Excel 2016, we also provide instructions for JMP Student Edition 14 and R. This provides students exposure to and experience with the current versions of several of the most commonly used software for statistical analysis in business. Excel 2016 and JMP appendices are contained within the textbook chapters, while R appendices are provided in MindTap Reader. In this latest edition, we no longer provide discussion of the use of Minitab.

- **Case Problems.** We have added 12 new case problems in this edition; the total number of cases is now 42. One new case on graphical display has been added to Chapter 2. Two new cases using discrete probability distributions have been added to Chapter 5, and one new case using continuous probability distributions has been added to Chapter 6. A new case on hypothesis testing has been added to Chapter 11, and two new cases on testing proportions have been added to Chapter 12. The Chapter 16 case on regression model building has been updated. A new case utilizing nonparametric procedures has been added to Chapter 18, and a new case on sample survey has been added to Chapter 22. The 42 case problems in this book provide students the opportunity to work on more complex problems, analyze larger data sets, and prepare managerial reports based on the results of their analyses.
- **Examples and Exercises Based on Real Data.** In this edition, we have added headers to all Applications exercises to make the application of each problem more obvious. We continue to make a substantial effort to update our text examples and exercises with the most current real data and referenced sources of statistical information. We have added more than 160 new examples and exercises based on real data and referenced sources. Using data from sources also used by *The Wall Street Journal*, *USA Today*, *The Financial Times*, and others, we have drawn from actual studies and applications to develop explanations and create exercises that demonstrate the many uses of statistics in business and economics. We believe that the use of real data from interesting and relevant problems helps generate more student interest in the material and enables the student to learn about both statistical methodology and its application. The 14th edition contains more than 350 examples and exercises based on real data.

Features and Pedagogy

Authors Anderson, Sweeney, Williams, Camm, Cochran, Fry, and Ohlmann have continued many of the features that appeared in previous editions. Important ones for students are noted here.

Methods Exercises and Applications Exercises

The end-of-section exercises are split into two parts, Methods and Applications. The Methods exercises require students to use the formulas and make the necessary computations. The Applications exercises require students to use the chapter material in real-world situations. Thus, students first focus on the computational "nuts and bolts" and then move on to the subtleties of statistical application and interpretation.

Margin Annotations and Notes and Comments

Margin annotations that highlight key points and provide additional insights for the student are a key feature of this text. These annotations, which appear in the margins, are designed to provide emphasis and enhance understanding of the terms and concepts being presented in the text.

At the end of many sections, we provide Notes and Comments designed to give the student additional insights about the statistical methodology and its application. Notes and Comments include warnings about or limitations of the methodology, recommendations for application, brief descriptions of additional technical considerations, and other matters.

Data Files Accompany the Text

Over 200 data files accompany this text. Data files are provided in Excel format and step-by-step instructions on how to open Excel files in JMP are provided in Appendix 1.1. Files for use with R are provided in comma-separated-value (CSV) format for easy loading into the R environment. Step-by-step instructions for importing CSV files into R are provided in MindTap Reader Appendix R 1.2.

The data files can be accessed from WebAssign within the resources section, directly within the MindTap Reader by clicking on the DATAfile icon, or on the publisher's website at https://login.cengage.com.

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Chapter 1

Data and Statistics

CONTENTS

STATISTICS IN PRACTICE

Bloomberg Businessweek*

NEW YORK, NEW YORK

Bloomberg Businessweek is one of the most widely read business magazines in the world. Along with feature articles on current topics, the magazine contains articles on international business, economic analysis, information processing, and science and technology. Information in the feature articles and the regular sections helps readers stay abreast of current developments and assess the impact of those developments on business and economic conditions.

Most issues of *Bloomberg Businessweek* provide an in-depth report on a topic of current interest. Often, the in-depth reports contain statistical facts and summaries that help the reader understand the business and economic information. Examples of articles and reports include the impact of businesses moving important work to cloud computing, the crisis facing the U.S. Postal Service, and why the debt crisis is even worse than we think. In addition, *Bloomberg Businessweek* provides a variety of statistics about the state of the economy, including production indexes, stock prices, mutual funds, and interest rates.

Bloomberg Businessweek also uses statistics and statistical information in managing its own business. For example, an annual survey of subscribers helps the company learn about subscriber demographics, reading habits, likely purchases, lifestyles, and so on. *Bloomberg Businessweek* managers use statistical summaries from the survey to provide better services to subscribers and advertisers. One North American subscriber survey indicated that 64% of *Bloomberg Businessweek* subscribers are involved with computer purchases at work. Such statistics alert *Bloomberg Businessweek* managers to subscriber interest in articles about new developments in computers. The results of the subscriber survey are also made available to potential advertisers. The high percentage of subscribers involved with computer purchases at work would be an incentive for a computer manufacturer to consider advertising in *Bloomberg Businessweek*.

Bloomberg Businessweek uses statistical facts and summaries in many of its articles. AP Images/Weng lei-Imaginechina

In this chapter, we discuss the types of data available for statistical analysis and describe how the data are obtained. We introduce descriptive statistics and statistical inference as ways of converting data into meaningful and easily interpreted statistical information.

*The authors are indebted to Charlene Trentham, Research Manager, for providing the context for this Statistics in Practice.

Frequently, we see the following types of statements in newspapers and magazines:

- Unemployment dropped to an 18-year low of 3.8% in May 2018 from 3.9% in April and after holding at 4.1% for the prior six months (*Wall Street Journal,* June 1, 2018).
- Tesla ended 2017 with around $5.4 billion of liquidity. Analysts forecast it will burn through $2.8 billion of cash this year (*Bloomberg Businessweek,* April 19, 2018).
- The biggest banks in America reported a good set of earnings for the first three months of 2018. Bank of America and Morgan Stanley made quarterly net profits of $6.9 billion and $2.7 billion, respectively (*The Economist,* April 21, 2018).
- According to a study from the Pew Research Center, 15% of U.S. adults say they have used online dating sites or mobile apps (*Wall Street Journal,* May 2, 2018).

- According to the U.S. Centers for Disease Control and Prevention, in the United States alone, at least 2 million illnesses and 23,000 deaths can be attributed each year to antibiotic-resistant bacteria (*Wall Street Journal,* February 13, 2018).

The numerical facts in the preceding statements—3.8%, 3.9%, 4.1%, $5.4 billion, $2.8 billion $6.9 billion, $2.7 billion, 15%, 2 million, 23,000—are called **statistics**. In this usage, the term *statistics* refers to numerical facts such as averages, medians, percentages, and maximums that help us understand a variety of business and economic situations. However, as you will see, the subject of statistics involves much more than numerical facts. In a broader sense, statistics is the art and science of collecting, analyzing, presenting, and interpreting data. Particularly in business and economics, the information provided by collecting, analyzing, presenting, and interpreting data gives managers and decision makers a better understanding of the business and economic environment and thus enables them to make more informed and better decisions. In this text, we emphasize the use of statistics for business and economic decision making.

Chapter 1 begins with some illustrations of the applications of statistics in business and economics. In Section 1.2 we define the term *data* and introduce the concept of a data set. This section also introduces key terms such as *variables* and *observations,* discusses the difference between quantitative and categorical data, and illustrates the uses of cross-sectional and time series data. Section 1.3 discusses how data can be obtained from existing sources or through survey and experimental studies designed to obtain new data. The uses of data in developing descriptive statistics and in making statistical inferences are described in Sections 1.4 and 1.5. The last four sections of Chapter 1 provide an introduction to business analytics and the role statistics plays in it, an introduction to big data and data mining, the role of the computer in statistical analysis, and a discussion of ethical guidelines for statistical practice.

1.1 Applications in Business and Economics

In today's global business and economic environment, anyone can access vast amounts of statistical information. The most successful managers and decision makers understand the information and know how to use it effectively. In this section, we provide examples that illustrate some of the uses of statistics in business and economics.

Accounting

Public accounting firms use statistical sampling procedures when conducting audits for their clients. For instance, suppose an accounting firm wants to determine whether the amount of accounts receivable shown on a client's balance sheet fairly represents the actual amount of accounts receivable. Usually the large number of individual accounts receivable makes reviewing and validating every account too time-consuming and expensive. As common practice in such situations, the audit staff selects a subset of the accounts called a sample. After reviewing the accuracy of the sampled accounts, the auditors draw a conclusion as to whether the accounts receivable amount shown on the client's balance sheet is acceptable.

Finance

Financial analysts use a variety of statistical information to guide their investment recommendations. In the case of stocks, analysts review financial data such as price/earnings ratios and dividend yields. By comparing the information for an individual stock with information about the stock market averages, an analyst can begin to draw a conclusion as to whether the stock is a good investment. For example, the average dividend yield for the S&P 500 companies for 2017 was 1.88%. Over the same period, the average dividend yield for Microsoft was 1.72% (Yahoo Finance). In this case, the statistical information on dividend yield indicates a lower dividend yield for Microsoft