



RONALD M. WEIERS



INTRODUCTION TO BUSINESS STATISTICS



SECOND
EDITION

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RONALD M. WEIERS

Indiana University of Pennsylvania

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A note about the cover: Essential statistical concepts are evident in the workings of both natural and man-made objects all around us. Each image shown on the cover offers a visual analogy to a statistical concept that is extensively used in business. For example, the ferris wheel suggests the concept of multiple regression and correlation, but it also depicts the business of amusement parks, where risk management is a vital concern. Likewise, the suspension bridge being struck by lightning represents the concept of probability and at the same time implies that a maintenance budget for bridge repair can be determined more accurately by anticipating and accounting for the occurrence of rare events. Each photograph on the cover reappears within the textbook at the beginning of the chapter dealing with the statistical concept with which the photograph most closely corresponds. The cover and chapter-opening photographs were selected based on the assumption that abstract statistical ideas can often be forcefully conveyed through concrete physical images.

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To the fond memories of my best friend ever, Mr. Barney Jim,
to making some memories with my new grandson, Connor Reilly,
and to Peg, Janice, Jennifer, Bob, Pam, and Nancy with love.

THE DRYDEN PRESS SERIES IN MANAGEMENT SCIENCE AND QUANTITATIVE METHODS

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*Statistics I: Descriptive Statistics and
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*Statistics II: Estimation and Tests of
Hypothesis*

P R E F A C E



Philosophies and Goals of the Text: A Message to the Student

A book is a very special link between author and reader. In a mystery novel, the author presents the reader with a maze of uncertainty, perplexity, and general quicksand. Intellectual smokescreens are set up all the way to the “whodunit” ending. Unfortunately, many business statistics texts seem to be written the same way—except for the “whodunit” section. This text is specifically designed to be different. Its goals are: (1) to be a friendly guide as you learn about business statistics, (2) to avoid quicksand that could inhibit either your interest or your learning, and (3) to earn and retain your trust in our ability to accomplish goals 1 and 2.

The chapters that follow are designed to be both informal and informative, as befits an introductory text in business statistics. You will not be expected to have had mathematical training beyond simple algebra, and mathematical symbols and notations will be explained as they become relevant to our discussion. Following an introductory explanation of the purpose and the steps involved in each technique, you will be provided with several down-to-earth examples of its use. Each section has a set of exercises based on the section contents. At the end of each chapter you’ll find a summary of what you’ve read and a listing of equations that have been introduced, as well as a demonstration problem, chapter exercises, a minicase, and a computer database exercise to help you practice your skills. A self-test is provided to help you evaluate how well you’ve learned the material.

Features of the Text

The Use of Examples

Each chapter is packed with examples to illustrate the techniques within, and, whenever possible, they are of a scale that permits solution with a pocket calculator. In addition to describing a technique and presenting a pocket calculator example of its application, we will typically present one or more MINITAB printouts that show how the problem can be handled with this popular statistical package. This pedagogical strategy is used so the reader will have a greater appreciation for what’s going on inside the computer when it must be applied to problems of a larger scale.

As pocket calculators have become more advanced, the need for statistical tables has been reduced. For example, we will assume that the reader’s pocket calculator is capable of such functions as computing logarithms and generating squares and square roots. In

days gone by, it was not unusual for statistics texts to include separate tables for capabilities that are now offered in even the lower echelon of pocket calculators.

The Use of Real Data

The value of statistical techniques becomes more apparent through the consistent use of real data in the text. Data sets, gathered from such publications as *Fortune 500*, *Newsweek*, and *The Wall Street Journal*, are used in more than 500 exercises and examples to make statistics both relevant and interesting for students.

The Computer

The combination of more powerful microcomputers and the statistical software designed specifically for them has revolutionized the world of statistics and data analysis. Statistical packages such as SPSS, SAS, SYSTAT, and MINITAB are among those formerly available only for mainframe computers, but which now can be applied by the microcomputer user. While the principles are the same, the convenience is markedly improved. In addition, strictly microcomputer packages are proliferating at a rapid rate.

The text includes computer output from several statistical packages, primarily MINITAB, one of the most popular packages used in the teaching of business statistics. Printouts from MICROSTAT and MYSTAT (the student version of SYSTAT) are also provided. MINITAB and MYSTAT are “command-driven” in that the user must communicate with the computer by means of specific commands telling it what data manipulations or analyses to perform. Each printout from these packages is accompanied by the command(s) that generated the output. MICROSTAT, designed strictly for the microcomputer, is “menu-driven” and the user need only select from a list of alternatives displayed on the screen. Depending on which choice is made from the main menu, other menus will appear as they become appropriate, and the user need only type in a letter or number to proceed to the next stage of data handling or analysis.

Each of the approximately 200 computer printouts is completely interpreted and linked to a concept or example presented earlier in its respective chapter. Whether or not the reader is using a computer statistical package in conjunction with the course, he or she should find that these printouts enhance the learning process. To illustrate the principles of the techniques discussed in the text, many of our examples will be on a scale that allows hand calculation. However, in many of these cases the corresponding computer output will also be presented, as a means of supplementing the student’s learning experience with a “computer’s-eye” view of the same analysis.

The text also follows the continuing saga of Grandfather (Luke) and Grandson (Ted) Thorndike in their application of chapter concepts to Thorndike Sports Equipment. At the end of each chapter, the reader will have the opportunity to help them apply statistical concepts to their business. In many of the Thorndike adventures, a computer statistical package will be a helpful, but optional, partner.

Computer database exercises provide the opportunity to apply chapter concepts and a computer statistical package to a real-world database, the Springdale Shopping Survey. Only the names have been changed, and the numbers represent the opinions and behaviors of real people in a real community. The entire database contains 38 variables for 200 respondents. With 7600 data points, the database is large enough to allow a wide variety of statistical questions, but small enough that the reader will not have to take a nap while his or her microcomputer is working on them. This and additional databases (including shortened versions for those using the student editions of computer statistical packages such as MINITAB) are also available on the data diskette, to be discussed in the Ancillary Items section.

Unique Chapters

In our competitive global economy, product quality is increasingly important to manufacturers and consumers alike, and Chapter 18, Total Quality Management, introduces the student to selected ideas and techniques that are in widespread use in this vital field. As in the core chapters, heavy emphasis is given to the application of computer statistical packages in facilitating total quality management. While the chapter is not intended to prepare the reader for an immediate position in the field, he or she will gain a new perspective regarding the importance of TQM and the role that statistics plays in it.

Whether carrying out one's own investigation or evaluating a study that was done by someone else, it's helpful to have at least an introductory knowledge of how business research is typically carried out. Chapter 20, Business and Survey Research, discusses primary versus secondary data, the research process, survey research and questionnaire design, and the conduct of experiments and observational research. A brief summary of some of the more well-known published and other secondary data sources is provided, along with a discussion of how to go about evaluating the applicability and the quality of such information. Chapter 20 is intended to reinforce the fact that data such as those presented in exercises and examples throughout the book do not simply materialize: They are the result of business research efforts relevant to a real-world business problem or situation.

To the knowledge of the author and publisher, never before has an introductory business statistics textbook included a separate chapter like Chapter 21, Ethics in Statistical Analysis and Reporting. In the United States, polling seems to have become a national obsession, and unscientific surveying and sampling methods abound—e.g., “900-number” polls and “person-on-the-street” interviews. Also, the results of data analysis are often strategically clouded with jargon that is specifically designed to sell a conclusion while at the same time masking the path through which it was reached. In sum, Chapter 21 is designed to promote healthy skepticism and to facilitate personal self-defense for the consumer of statistical findings offered by others.

Organization of the Text

The text can be used in either a one-term or a two-term course. For one-term applications, Chapters 1 through 10 are suggested. For two-term use, it is recommended that the first term include Chapters 1 through 10, and that the second term include Chapters 11 through 17. In either one- or two-term use, the number and variety of chapters allow for instructor flexibility in designing either a course or a sequence of courses that will be of maximum benefit to the student. This flexibility includes the possibility of including one or more of the four remaining chapters, which are in the Special Topics section of the text.

Chapter 1 provides an introductory discussion of business statistics and its relevance to the real world. Chapters 2 and 3 cover visual summarization methods and descriptive statistics used in presenting statistical information. In Chapters 4 through 6, we discuss the basic notions of probability and go on to introduce the discrete and continuous probability distributions upon which many statistical analyses depend. In Chapters 7 and 8, the philosophies and methods of sampling and generalizing upon sample findings are discussed.

Chapters 9 through 13 focus on the use of sample data to reach conclusions regarding the phenomena that the data represent. In these chapters, the reader will learn how to use statistics in deciding whether or not to reject statements that have been made concerning

these phenomena. In Chapters 14 and 15, methods are introduced that allow us to employ equations in describing how one variable tends to change in response to changes in one or more others.

Chapters 16 and 17 examine time series, forecasting, and index number concepts used in analyzing data that occur over a period of time. Chapter 18 examines total quality management and its utilization of statistics, while Chapter 19 discusses the role of statistics in decision theory. Chapter 20 examines some of the popular approaches by which statistical data are collected or generated.

In Chapter 21, statistics and its practitioners are discussed in terms of larger social and ethical implications. At the end of the text, there is a helpful glossary of the key terms presented in the book, a set of statistical tables, answers to selected exercises, and answers to the self-test questions at the end of each chapter. For convenience, the front and rear endsheets contain the two statistical tables to which the reader will most often be referring: the standard normal distribution and the t distribution.

The problems and examples contained in the text represent an extremely diverse selection of business settings, ranging from airlines to hospitals, marketing to manufacturing, personnel to shipping, and sports teams to zoos. Such diversity is important, since readers will be concentrating on a wide variety of business disciplines and headed for equally diverse business careers.

What's New in the Second Edition

The Missouri Rule

Named for the “Show Me” state and making its published debut in the Second Edition, the Missouri Rule applies to the directionality of null and alternative hypotheses in one-tail testing. It can be invoked whenever a testing situation involves a verbal statement that is both (1) a directional inequality (either $>$ or $<$, not \geq or \leq) and (2) boastful about the margin by which a parameter differs from a specified value—for example, someone brags about a population mean or proportion as “greatly exceeding” or being “well under” some numerical value. In this event, we may wish to put the burden of proof on this individual—that is, formulate null and alternative hypotheses in such a way that we will not believe him unless the test result is strongly in the same direction as his contention. For more details, see Chapter 9, Hypothesis Tests Involving a Sample Mean or Proportion, and Table 9.1.

Total Quality Management

Successful firms are aware that the old-fashioned strategy of pursuing quality through defect *detection* is a loser in today's competitive environment. Producers of world-class goods and services now rely heavily on Total Quality Management (TQM) and its philosophy of defect *prevention*. We have tried to bring the Second Edition to the cutting edge of TQM, its advocates, philosophies, statistical tools, and facilitating practices. Chapter 18, Total Quality Management, is also designed to *inspire* as well as inform the reader—along with its various concrete manifestations, TQM is also very much a state of mind. Discussions such as the one regarding the Kaizen philosophy are but a humble attempt to convey this very important truth.

Other In-Chapter Improvements

The visual and statistical approaches to describing data are now divided into two chapters (2 and 3) to be both more readable and less imposing. The Second Edition includes selected exercises requiring more verbal reasoning and written expression on the part of the student. For example, Exercises such as 5.53, 5.95, 5.96, 6.96, 7.93, 8.75, and 8.76 may inquire as to why a particular technique was chosen or ask what an answer actually *means*, instead of just what its numerical value happens to be. The Durbin-Watson test for autocorrelation is now included in Chapter 16, Models for Time Series and Forecasting—its coverage has been designed to be self-sufficient and the topic can easily be covered earlier in the course for instructors who wish to do so.

Thorndike Sports Equipment Video Cases

The chapter minicases with Luke and Ted Thorndike have been elevated to a new level. Like the wooden kid in Pinocchio, the crusty critter and his grandson have come to life. Many of their statistical adventures have been dramatized in uncanny realism and are now available on a VCR near you.

Other Ancillary Improvements

The Test Bank is entirely new and incorporates a much greater depth and variety of objective test questions. The Solutions Manual remains perhaps the most extensive and detailed available, and now includes manual calculations to complement the computer solutions that were previously used for many of the exercises.

Ancillary Items

To further enhance the usefulness of the text, a complete package of ancillary items has been assembled.

Instructor's Manual (Weiers)

This manual contains suggested syllabi, possible class projects and special assignments, and additional discussion and examples, including relevant computer analyses that utilize a second major computer database. The manual also includes approximately 100 transparency masters that are based on key figures and tables in the text and features Student-Edition MINITAB solutions to the Computer Database Exercises.

Solutions Manual (Mock and Weiers)

Solutions to the over 1500 exercises in the textbook, with each exercise classified according to type (definition, computation, and problem-solving), tools required (pencil, calculator, computer), and level of difficulty (easy, medium, difficult). The solutions manual also contains annotated answers to the end-of-chapter self-test questions as well as solutions to the Thorndike Minicases and full MINITAB solutions to the Computer Database Exercises.

Test Bank (Key and Solomon)

There are over 1100 test questions, with about 100 for each of the core chapters in the text. The questions include true-false, multiple-choice, and problems similar to those at the ends of the chapters. Questions are classified according to level of difficulty and are referenced to a specific page in the text.

Computerized Test Bank

Adopters with IBM-compatible or Apple computers can use the available ExaMaster software to tailor examinations to their particular students and course format. For a given examination, up to 99 different versions can be printed.

Request

This additional service, provided by the publisher, allows the instructor to use a toll-free number to receive test masters (by mail or fax) according to question number and/or selection criteria.

Study Guide (Chaffe-Stengel and Stengel)

A useful and easy-to-read supplement. Each chapter of the *Study Guide* includes an outline in the form of a logical flow chart connecting major text ideas, selected annotated solutions, and additional exercises.

Software Conversions Guide (Young)

Included with every text purchased, this laminated card provides students with the equivalent commands for performing common input/output and analysis procedures with four major statistical software packages: MINITAB, MYSTAT, SAS, and SPSS.

Data Disk (Taiani and Weiers)

Also available to instructors, this diskette includes data for the Springdale Shopping Survey that is the topic of most of the computer database exercises in the text. As a unique feature, the appendix table of random digits is also provided in electronic form as a computer database to facilitate computer analysis and to demonstrate chapter principles. To enhance course flexibility, a database from another real-world survey (Wendy's) is featured in the *Instructor's Manual*, and this database is also included on the data diskette. All three databases are provided in both ASCII and MINITAB worksheet (*.MTW suffix) formats.

For those using the student editions of packages like MINITAB, shortened versions of all three databases are also provided—each in ASCII and MINITAB formats. The following data files are on the data diskette:

README.TXT Text file discussing the files on the data diskette, including format information for the ASCII files. The README.TXT file is an ASCII file accessible with most word processors and contains the latest available information pertaining to the data diskette and the use of its data files.

SHOPPERS.DAT Springdale Shopping Survey ASCII

SHOPLITT.DAT Springdale ASCII (shortened)

SHOPPERS.MTW Springdale MINITAB

SHOPLITT.MTW Springdale MINITAB (shortened, for Student Edition of MINITAB)

RANDNUMB.DAT Table of random digits ASCII

RANDLITT.DAT Table of random digits ASCII (shortened)

RANDNUMB.MTW Table of random digits MINITAB

RANDLITT.MTW Table of random digits MINITAB (shortened, for Student Edition of MINITAB)

Also, pertaining to the *Instructor's Manual* and its additional examples:

WENDYS.DAT Wendy's survey ASCII

WENDLITT.DAT Wendy's ASCII (shortened)

WENDYS.MTW Wendy's MINITAB

WENDLITT.MTW Wendy's (shortened, for Student Edition of MINITAB)

The inclusion of MINITAB-specific data files allows the MINITAB user to avoid having to recode (.) missing-data values to the (*) values that MINITAB expects. To make computer involvement as convenient as possible, additional variants may appear in response to adopter requests, so be sure to view the README.TXT file on the data diskette for the very latest information describing the database files and how to use them.

Available Software EDUSTAT (Young)

The Dryden Press computer statistical package is available free of charge for class reproduction. Also, MYSTAT, the PC version of SYSTAT, will be available as a packaging option for instructors interested in this particular software.

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Ronald M. Weiers, Ph.D.
Indiana University of Pennsylvania
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B R I E F C O N T E N T S



PART ONE	BUSINESS STATISTICS: INTRODUCTION AND BACKGROUND 1
	1 A Preview of Business Statistics 2
	2 Visual Description of Data 17
	3 Statistical Description of Data 60
PART TWO	PROBABILITY 111
	4 Probability: Review of Basic Concepts 112
	5 Discrete Probability Distributions 169
	6 Continuous Probability Distributions 230
PART THREE	SAMPLING 293
	7 Sampling and Sampling Distributions 294
	8 Estimation from Sample Data 343
PART FOUR	HYPOTHESIS TESTING 399
	9 Hypothesis Tests Involving a Sample Mean or Proportion 400
	10 Hypothesis Tests Involving Two Sample Means or Proportions 462
	11 Analysis of Variance Tests 518
	12 Chi-Square Applications 596
	13 Nonparametric Methods 654
PART FIVE	REGRESSION AND CORRELATION, TIME SERIES AND INDEX NUMBERS 725
	14 Simple Linear Regression and Correlation 726
	15 Multiple Regression and Correlation 792
	16 Models for Time Series and Forecasting 859
	17 Index Numbers 921
PART SIX	SPECIAL TOPICS 953
	18 Total Quality Management 954
	19 Decision Theory 1016
	20 Business and Survey Research 1053
	21 Ethics in Statistical Analysis and Reporting 1075
APPENDIX A	STATISTICAL TABLES
APPENDIX B	SELECTED ANSWERS

C O N T E N T S



PART ONE

BUSINESS STATISTICS: INTRODUCTION AND BACKGROUND 1

CHAPTER 1

A Preview of Business Statistics 2

- 1.1 Introduction 2
 - Timely Topic, Tattered Image* 2
 - What Is Business Statistics?* 2
 - For the Consumer as Well as the Practitioner* 3
 - 1.2 Statistics: Yesterday and Today 3
 - Yesterday* 3
 - Today* 4
 - 1.3 Descriptive versus Inferential Statistics 5
 - Descriptive Statistics* 5
 - Inferential Statistics* 5
 - 1.4 Types of Variables and Scales of Measurement 8
 - Qualitative Variables* 8
 - Quantitative Variables* 8
 - Scales of Measurement* 9
 - 1.5 Statistics in Business Decisions 11
 - 1.6 Business Statistics: Tools versus Tricks 12
- STATISTICS IN ACTION 1.1**
Two Tales of Texas 12
- 1.7 Summary 13

CHAPTER 2

Visual Description of Data 17

- 2.1 Introduction 17
- 2.2 The Data Array and the Frequency Distribution 17
 - The Data Array* 18
 - The Frequency Distribution* 19
- 2.3 Constructing a Frequency Distribution 20
 - Key Terms* 20
 - Guidelines for the Frequency Distribution* 21

Relative and Cumulative Frequency Distributions 25

2.4 The Stem and Leaf Display 28

2.5 Visual Representation of the Data 31

Popular Graphical Methods 31**STATISTICS IN ACTION 2.1**

These Words are Better than an Eighth of a Picture 39

The Abuse of Visual Displays 40

2.6 Visual Data Description and the Computer 44

2.7 Summary 46

CHAPTER 3**Statistical Description of Data 60**

3.1 Introduction 60

3.2 Statistical Description: Measures of Central Tendency 61

The Arithmetic Mean 61*The Weighted Mean* 62*The Median* 64**STATISTICS IN ACTION 3.1**

Battling the Averages 64

The Mode 65**STATISTICS IN ACTION 3.2**

The United States, a People of Means 65

Comparison of the Mean, Median, and Mode 66*Distribution Shape and Measures of Central Tendency* 66**STATISTICS IN ACTION 3.3**

U.S. Males Post Skewed Incomes 69

3.3 Statistical Description: Measures of Dispersion 71

Range 72*Quantiles* 73*Mean Absolute Deviation (MAD)* 74*Variance and Standard Deviation* 75

3.4 Additional Dispersion Topics 80

Chebyshev's Theorem 80*Standardized Data* 80*The Coefficient of Variation* 82

3.5 Descriptive Statistics and the Computer 84

The Box-and-Whisker Plot 86*Standardizing a Set of Data* 87

3.6 Descriptive Statistics from Grouped Data 89

Arithmetic Mean from Grouped Data 90*Variance and Standard Deviation from Grouped Data* 91*A Closing Note* 91