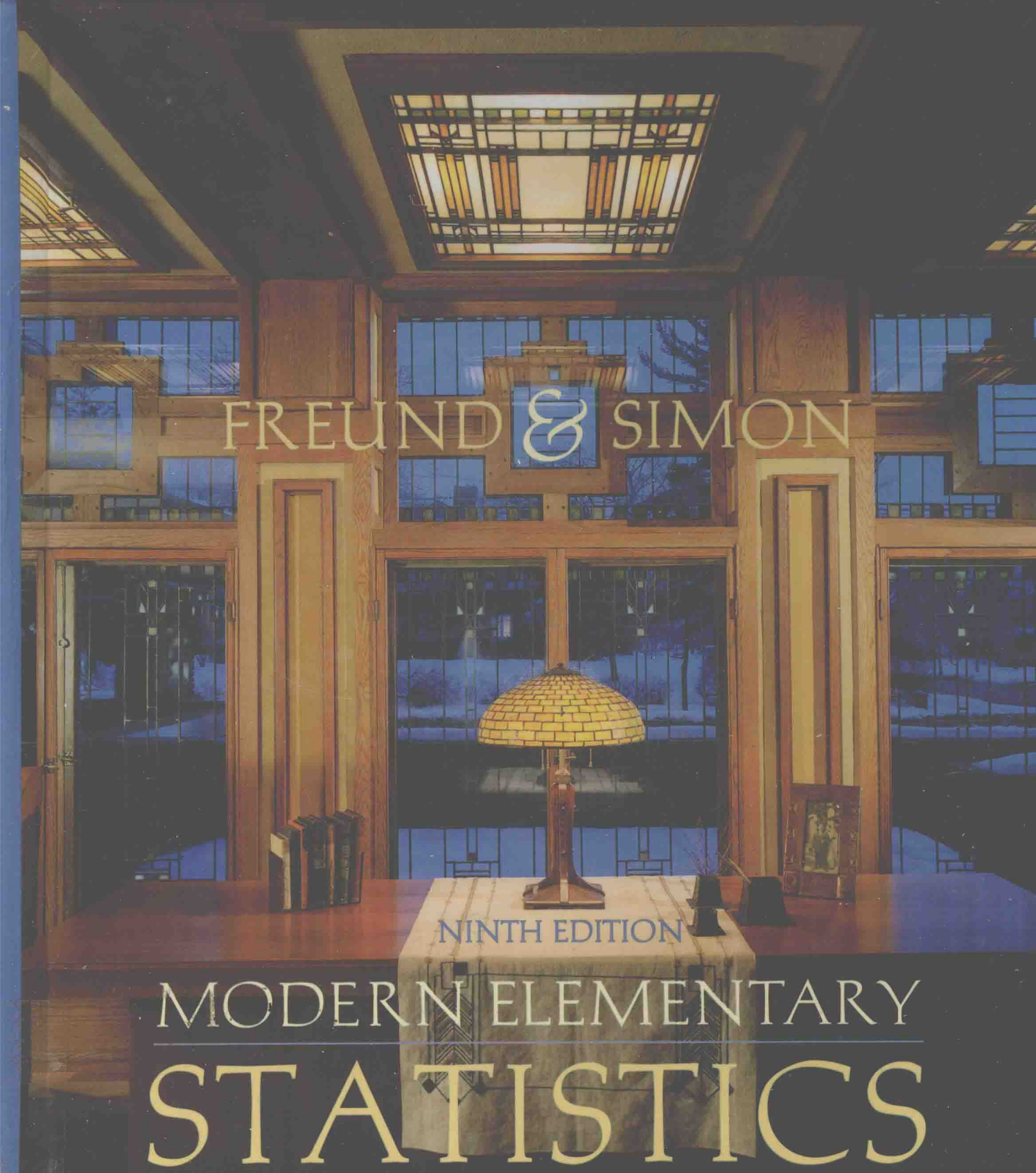
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NINTH EDITION
MODERN ELEMENTARY
STATISTICS

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REVISED

MODERN ELEMENTARY STATISTICS

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PREFACE

The principal objective for this, the ninth edition of *Modern Elementary Statistics,* is to introduce beginning students to the fundamental ideas of modern statistics. The organization of the text is unchanged, but there are modifications in content, emphasis, and visual presentation.

This ninth edition contains some 1400 exercises that involve both conceptual and computational challenges. Our purpose here is to make the reader familiar with the mechanics of calculations but also to think about the relevance of techniques introduced.

This edition offers greater opportunity for the student to use the computer in the study of statistics. The computer is spectacularly effective for producing graphic displays such as scatter plots and box-and-whisker plots, and can be used to great advantage to simulate values of random variables in connection with the law of large numbers or the sampling distribution of the mean; to determine tail probabilities for the values of n and p not found in tables and thus ascertain the proximity of the Poisson approximation to the binomial. Moreover, the computer is indispensable for multiple-regression computations that are intricate and not amenable to manual calculation.

We do not state specifically the subjects, sections, or chapters to study, but we do indicate which topics can be omitted without loss of continuity. Such "optional" sections are identified by an icon, ⏢, preceding the topic heading. For example, some instructors will not cover the material on grouped data, yet those who must deal with published government data may consider it essential.

NEW TO THIS EDITION

Supplementing the innovations highlighted as follows, this edition is enhanced by an "open" style of presentation, meaning that important equations or statements and lists of data are displayed rather than embedded in the text.

topic selection

The selection of topics for this text has evolved during its eight preceding editions, and the experience and classroom use implied by the wide, implicit acceptance of its presentation. Additionally, for this edition we have included, in Chapter 14, material concerning multiple comparisons. As a logical follow-up to comparative experiments, frequently involving consumer goods, decisions concerning the relative merits of individual products must be made; this section provides guidance for that process.

computer printouts

Illustrated copiously with computer output, this edition uses MINITAB 10 for Windows, for which most of the commands are executed by using menus. As the menu item is selected, this program creates automatically the command code familiar to previous releases of MINITAB. In this edition the command code illustrates the applications. Instructors should have no difficulty in using this text with other software packages.

reduced complexity of exercises

In the early chapters the student will make computations of the form Σx, Σx^2, and $\Sigma (x - \bar{x})^2$ during the process of learning about the mean and the standard deviation. For the more advanced topics, later in the book, the exercises simply present the student with values of $\bar{x}$ and s, rather than requiring that these be computed from raw data. Thus, students can devote their concentration to the new subject and avoid calculations related to topics studied previously.

icons to classify exercises

Three icons are used for the reader's convenience: The icon  precedes exercises requiring computer software. The more challenging exercises are denoted by the symbol . Finally, the icon  is used to flag exercises related to the material covered in "optional" sections. Occasionally, more than one icon may apply to a given exercise.

data disk

Exercise data sets are now provided on disk. These exercises pertain to topics requiring extensive data entries.

acknowledgments

Our appreciation goes to our colleagues and students for their helpful suggestions and reviews of the present as well as preceding editions of this text. For this revision we are grateful to Leslie Ribera of the University of Central Oklahoma, Dee Oyler of Utah Valley State College, Louis Bianco of the University of Massachusetts at Dartmouth, David Lund of the University of Wisconsin at Eau Claire, and Bernard Okun of Brooklyn College for their helpful comments. We also thank Zhenhong Fan for his assistance in preparing the exercise solutions. Finally, our gratitude to our editors at Prentice Hall, Ann Heath and Millicent Treloar, and to Nicholas Romanelli for his help during the production process.

The revisions in the original version of the 9th edition of this book are entirely the work of Gary Simon.

GARY SIMON

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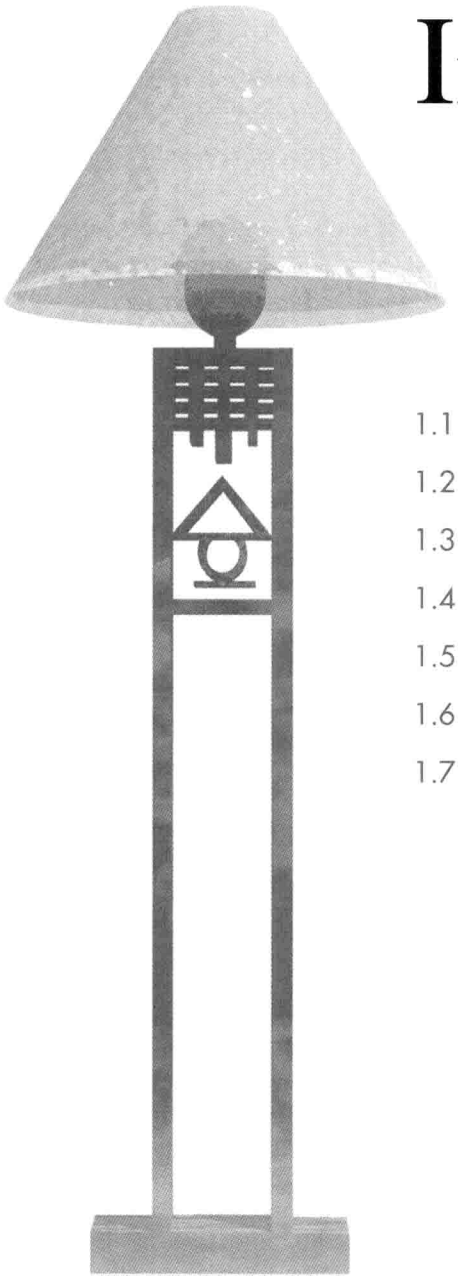
CHAPTER 1



INTRODUCTION

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1.3 Descriptive Statistics and Statistical Inference 5

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The collection, processing, interpretation, and presentation of numerical data all belong to the domain of statistics. These tasks include the calculation of baseball batting averages, collecting data on births and deaths, evaluating the effectiveness of commercial products, and forecasting the weather. Statistical information is presented to us constantly on radio and television. Our enthusiasm for statistical facts is encouraged by national newspapers such as The Wall Street Journal *and* USA Today.

The word "statistics" is used in several ways. It can refer not only to the mere tabulation of numeric information, as in reports of stock market transactions, but also to the body of techniques used in processing or analyzing data.

The word "statistician" is also used in several ways. The term can be applied to those who simply collect information, as well as to those who prepare analyses or interpretations, and it is also applied to scholars who develop the mathematical theory on which statistics is based.

In Sections 1.1 and 1.2 we discuss the recent growth of statistics and its ever-widening range of applications. In Section 1.3 we explain the distinction between the two major branches of statistics, descriptive statistics and statistical inference, and in the optional Section 1.4 we discuss the nature of various kinds of data and in connection with this warn the reader against the indiscriminate mathematical treatment of statistical data. ◩

1.1 THE GROWTH OF MODERN STATISTICS

There are several reasons why the scope of statistics and the need to study statistics have grown enormously in the last fifty or so years. One reason is the increasingly quantitative approach employed in all the sciences, as well as in business and many other activities which directly affect our lives. This includes the use of mathematical techniques in the evaluation of antipollution controls, in inventory planning, in the analysis of traffic patterns, in the study of the effects of various kinds of medications, in the evaluation of teaching techniques, in the analysis of competitive behavior of business managers and governments, in the study of diet and longevity, and so forth. The availability of powerful computers has greatly increased our ability to deal with numerical information. Many types of computers are also inexpensive, so that sophisticated statistical work can be done by small businesses, college students, and even high school students.

The other reason is that the amount of data that is collected, processed, and disseminated to the public for one reason or another has increased almost beyond comprehension, and what part is good statistics and what part is bad statistics is anybody's guess. To act as watchdogs, more and more persons with some knowledge of statistics are needed to take an active part in the collection of the data, in the analysis of the data, and, what is equally important, in all of the preliminary planning. Without the latter, it is frightening to think of all the

things that can go wrong in the compilation of statistical data. The results of costly surveys can be useless if questions are ambiguous or asked in the wrong way, if they are asked of the wrong persons, in the wrong place, or at the wrong time. Much of this is just common sense, as is illustrated by the following examples:

Example

To determine public sentiment about the continuation of a certain government program, an interviewer asks: "Do you feel that this wasteful program should be stopped?" Explain why this question will probably not yield the desired information.

solution

The interviewer is begging the question by suggesting, in fact, that the program is wasteful. ◩ ◩ ◩

Example

To study consumer reaction to a new convenience food, a house-to-house survey is conducted during weekday mornings, with no provisions for return visits in case no one is home. Explain why this approach may well yield misleading information.

solution

This survey will fail to reach those who are most likely to use the product: single persons and married couples with both spouses employed. ◩ ◩ ◩

Although much of the above-mentioned growth of statistics began prior to the computer revolution, the widespread availability and use of computers have greatly accelerated the process. In particular, computers enable us to handle, analyze, and dissect large masses of data, and they enable us to perform calculations which previously had been too cumbersome even to contemplate. Our objective in this book is your gaining an understanding of the ideas of statistics. Access to a computer is not critical for this objective. Computer uses are occasionally illustrated in this textbook, but nearly all the exercises can be done with nothing more than a four-function calculator.

1.2 THE STUDY OF STATISTICS

The subject of statistics can be presented at various levels of mathematical difficulty, and it may be directed toward applications in various fields of inquiry. Accordingly, many textbooks have been written on business statistics, educational statistics, medical statistics, psychological statistics, . . . , and even on statistics for historians. Although problems arising in these various disciplines will sometimes require special statistical techniques, none of the basic methods discussed in this book is restricted to any particular field of application. In the same way in which $2 + 2 = 4$ regardless of whether we are adding dollar amounts, horses, or trees, the methods we shall present provide **statistical models** which

apply regardless of whether the data are IQs, tax payments, reaction times, humidity readings, test scores, and so on. To illustrate this further, consider an exercise from Chapter 13, specifically exercise 13.104

13.104 In a random sample of 200 retired persons, 137 stated that they prefer living in an apartment to living in a one-family home. At the 0.05 level of significance does this refute the claim that 60 percent of all retired persons prefer living in an apartment to living in a one-family home?

The question asked here should be clear, and it should also be clear that the answer would be of interest mainly to social scientists or to persons in the construction industry. However, if we wanted to cater to the special interests of students of biology, engineering, education, or ecology, we might rephrase the exercise as follows:

13.104 In a random sample of 200 citrus trees exposed to a 20° frost, 137 showed some damage to their fruit. At the 0.05 level of significance does this refute the claim that 60 percent of all citrus trees exposed to a 20° frost will show some damage to their fruit?

13.104 In a random sample of 200 transistors made by a given manufacturer, 137 passed an accelerated performance test. At the 0.05 level of significance does this refute the claim that 60 percent of all the transistors made by the manufacturer will pass the test?

13.104 In a random sample of 200 high school seniors in a large city, 137 said that they will go on to college. At the 0.05 level of significance does this refute the claim that 60 percent of all the high school seniors in this city will go on to college?

13.104 In a random sample of 200 cars tested for the emission of pollutants, 137 failed to meet a state's legal standards. At the 0.05 level of significance does this refute the claim that 60 percent of all cars tested in this state will fail to meet its legal emission standards?

Insofar as the work in this book is concerned, the statistical treatment of all these versions of Exercise 13.104 is the same, and with some imagination the reader should be able to rephrase it for virtually any field of specialization. As some authors do, we could present, and so designate, special problems for readers with special interests, but this would defeat our goal of impressing upon the reader the importance of statistics in all of science, business, and everyday life. To attain this goal, we have included in this text exercises covering a wide spectrum of interests.

To avoid the possibility of misleading anyone with our various versions of Exercise 13.104, let us make it clear that we cannot squeeze all statistical problems into the same mold. Although the methods we study in this book are all widely applicable, it is always important to make sure that the statistical model we are using is the right one.

EXERCISES

1.1 Rephrase Exercise 13.104 referred to above, so that it will be of special interest to

(a) a cosmetics salesperson; (b) a musician; (c) a traffic engineer.

1.2 Bad statistics may well result from asking questions in the wrong way or of the wrong persons. Explain why the following may lead to useless data:

(a) To determine public sentiment about a certain foreign trade restriction, an interviewer asks voters: "Do you feel that this unfair practice should be stopped?"

(b) To predict a municipal election, a public opinion poll telephones persons selected haphazardly from the city's telephone directory.