BASIC STATISTICS

FOR BUSINESS AND ECONOMICS

Leonard J. Kazmier

BASIC STATISTICS FOR BUSINESS AND ECONOMICS

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STUDENTS: IF YOU WANT SOME EXTRA HELP . . .

This book was developed with special attention given to presenting statistical concepts and methods from a student-oriented viewpoint. However, if you want additional help, it will be worth your while to consider using the *Study Guide/Workbook to Accompany Basic Statistics for Business and Economics* by Norval F. Pohl and Leonard J. Kazmier. This supplement includes an overview of each chapter, a unique key-word diagram to help you master the concepts associated with statistical analysis, a summary of chapter content in simplified form, and "word" problems with step-by-step solutions. Your campus bookstore either has this manual in stock or can order it for you.

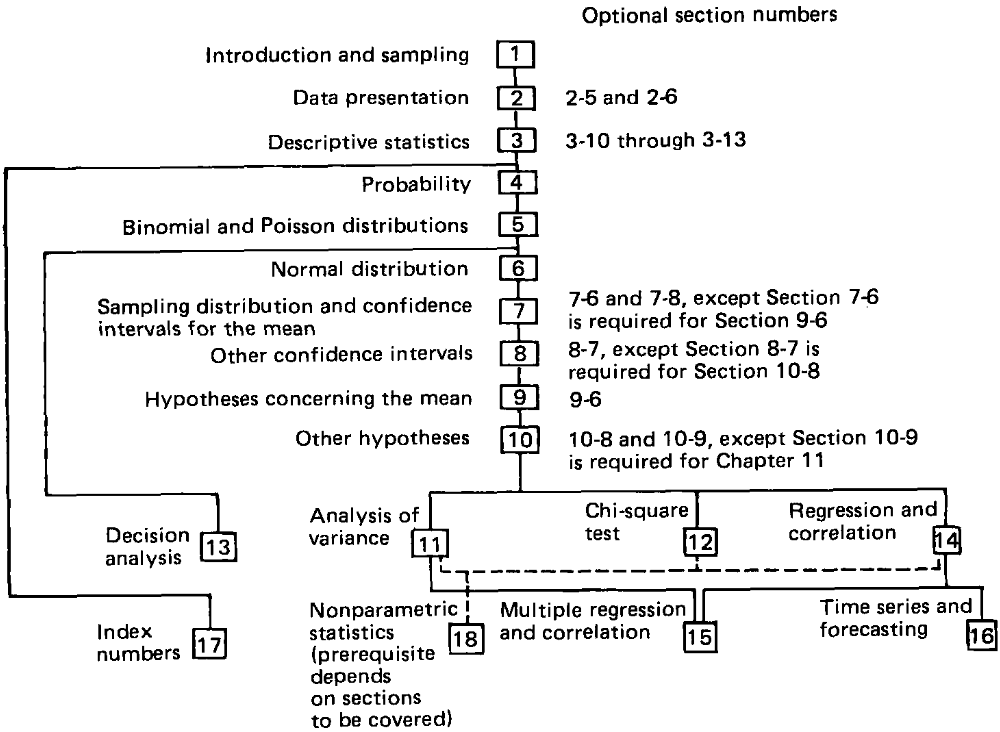
PREFACE

This book covers the methods of statistical description, probability, statistical inference, and decision analysis typically included in the first course in business and economic statistics. The mathematical prerequisite is basic college algebra. The development of this book reflects a special concern about presenting statistical concepts in terms that the *student* can understand, and with a variety of applications examples. Although this edition is the first, many of the explanations, examples, and exercises have been extensively class-tested through three editions of the programmed text, *Statistical Analysis for Business and Economics* (McGraw-Hill, 1978).

Because statistical inference based on sample data is the cornerstone of modern applications of statistical analysis, the methods of sampling that can be used for inference are described in Chapter 1. Following this introduction, the remainder of the first 10 chapters are devoted to the description of data, then to the essential concepts in probability, and finally to the methods of interval estimation and hypothesis testing, which are the principal techniques of statistical inference.

Depending on course and instructor objectives, many different patterns of topic coverage can be chosen beyond the first 10 chapters. The number of topics included is greater than the number than can be covered in the typical first course specifically so that alternative selection of topics is made possible. The diagram on the next page indicates the relationships among the topics in the numbered chapters. Sections in the first 10 chapters not required for later material are labeled as "optional." In Chapters 11 through 18 many sections are optional, and the coverage in these chapters is based entirely on instructor preference.

Appendix A includes a description of the use of computers in statistical analysis. Also included in the back section of the book are the answers to most of the end-of-chapter exercises. This information provides the student with the opportunity to determine whether particular answers are correct before proceeding to other exercises.



A supplementary manual, *Study Guide/Workbook to Accompany Basic Statistics for Business and Economics* by Norval F. Pohl and Leonard J. Kazmier, is available for use with this book. This workbook is organized in parallel form to the text in terms of chapter-by-chapter topic coverage. Included are a broad-brush overview for each chapter, a summary of chapter content in simplified form, and a unique key-word diagram that helps the student to master the concepts associated with statistical analysis. The problems in the workbook are designed to develop a student's competence in solving "word" problems by incorporating a step-by-step structured solution for each application.

The author expresses gratitude to the several anonymous reviewers who made suggestions regarding the development of this book. Special thanks are extended to Professor Zenon S. Malinowski of the University of Connecticut, Storrs, for a particularly penetrating review of the manuscript, to Donald E. Chatham and Charles E. Stewart of the McGraw-Hill Book Company for effective editorial supervision, and to Rolfe W. Larson for his work on this project at Hemisphere Publishing Corporation. Finally, the author is indebted to the literary executor of the late Sir Ronald A. Fisher, F.R.S., to Dr. Frank Yates, F.R.S., and to the Longman Group Ltd., London, for permission to adapt and reprint Tables III, IV, and VI from their book, *Statistical Tables for Biological, Agricultural, and Medical Research* (6th edition, Longman, 1974).

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CHAPTER

ONE

THE USE OF STATISTICS IN BUSINESS AND ECONOMICS

1-1 WHAT IS STATISTICS?
1-2 WHY STUDY STATISTICS?
1-3 INTERNAL AND EXTERNAL DATA
1-4 DESCRIPTIVE STATISTICS
1-5 INFERENTIAL STATISTICS
1-6 METHODS OF SAMPLING
1-7 SUMMARY
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1-1 WHAT IS STATISTICS?

Statistics is concerned with the techniques by which information is collected, organized, analyzed, and interpreted. Typically, most information analyzed is quantitative data and, particularly, data collected by the process of sampling. However, the techniques of statistics are not limited to quantitative sample data but can also include the analysis of historical information and even the judgments of managers about such uncertain values as the level of market demand for a new product. The theme unifying the diverse applications of statistics in business and economics is that ultimately some *decision* is made. In this sense, the applications of statistics in business are mainly concerned with *decision making under conditions of uncertainty.*

1-2 WHY STUDY STATISTICS?

Techniques of statistics are now used in all fields of business and economics. Indeed, it is difficult to imagine a person functioning as a manager in any field of business today without a good foundation in statistical analysis. Of course, a manager may not be directly involved in formal statistical analysis as such. But the understanding of statistics is important for two distinct reasons. First, statistical concepts and techniques represent a way of thinking that serves as the basis for orderly comparison of decision alternatives and greater effectiveness in decision making. Second, the demands of management often require the interpretation of statistical results reported by others and evaluation of conflicting claims that may result from the analysis of the same data. No manager can afford to accept on faith the opinion of "experts," and therefore he or she will want a basic foundation in statistics to evaluate such opinions independently.

The following examples represent some of the most common applications of statistics in business and economics.

An auditor is concerned with verifying the financial records of a large organization. Because it is not possible to verify the accuracy of every account receivable, the auditor selects a sample of accounts based on the techniques of statistics and from the sample results either accepts the accuracy of the stated amount of accounts receivable or continues with further sampling.

A production manager wishes to ascertain whether quality standards are being maintained. To accomplish this objective the production manager may have to test samples of the product and as a result of such tests may or may not have to make changes in the production process.

A personnel manager develops a new training program for sales personnel. Before implementing the program throughout the company, the personnel manager presents the program to a representative group of sales personnel and evaluates the results in comparison with other training and development methods.

A marketing manager is concerned about whether to market a new product. As a first step, the marketing manager could give a sample of the product to consumers for their use and evaluation. As another step before full-scale marketing, the marketing manager could carry out test marketing in limited geographic areas and then analyze the results to determine the likely level of overall demand.

An investment manager makes day-to-day decisions involving the choice of alternative investments. As the basis for these decisions, the investment manager incorporates the opinions of investment analysts and considers current governmental and business events as a basis for estimating the probability of various rates of return for each investment.

An economist needs to assess the impact of a proposed change in sales taxes in a given community in terms of consumer buying patterns. For his assessment the economist must first determine present buying patterns for different categories of consumers through field research. This determination will include interviews with samples of consumers in each major geographic area and in each income category.

The owner of a small business must decide how much of each item to order for inventory. Making this decision requires consideration of the likely level of demand, the cost of maintaining the item in inventory, and the cost of lost profit and lost goodwill if demand exceeds supply.

1-3 INTERNAL AND EXTERNAL DATA

Business data collected for analysis may be either internal or external, from the reference point of the individual firm. *Internal data*, data obtained within the firm itself, generally include such information as production levels, costs, and volume of sales. The internal records kept within a firm, such as the records pertaining to purchasing, receiving, sales, payroll, billing, and goods in process, serve as the primary source of internal data. The records maintained are concerned with both financial and nonfinancial data. For example, materials costs and payroll are essentially financial, while personnel records and quality-control data are nonfinancial.

External data, business data collected outside the firm, would include, for example, data on industry sales. When the data are available in published form, the source is considered as a *primary source* if it represents the original publication of the data. For example, the *Survey of Current Business*, published monthly by the Department of Commerce, is a primary source of statistics concerned with prices and volume of operations in a large number of industries. A *secondary source* of data is one that reproduces data from a primary source, sometimes along with other data being reported for the first time. Generally, external business data are more timely when obtained from primary rather than secondary sources. An example of a widely used secondary source of data is the *Statistical Abstract of the United States*, published annually by the Department of Commerce, which contains data from a variety of governmental and nongovernmental primary sources.

1-4 DESCRIPTIVE STATISTICS

Descriptive statistics is the collection of statistical techniques used to summarize and describe data and other types of information. For example, even though the financial page of a newspaper reports all price changes for stock issues traded on the New York Stock Exchange on a given day, it would be very difficult for the typical reader to interpret the overall price changes that day without some kinds of summary values. The *Dow Jones Industrial Average* and the *New York Stock Exchange Composite Index* are examples of descriptive values that summarize price data and therefore make price changes more meaningful.

In general, the methods of descriptive statistics include graphic techniques as well as quantitative summary values. For example, *bar charts, line graphs,* and *pie charts* can be used to portray business and economic data. The typical corporate annual report includes a variety of such graphic methods. Chapter 2 describes a number of techniques, including summary tables, charts, and graphs, by which data can be presented. The principal quantitative summary values used to describe sets of data are *measures of average* and *measures of dispersion*, or variability, in the data set. Again, the *Dow Jones Industrial Average* describes the price change in a selected group of industrial common stock issues, while the range of stock prices given on the financial page indicates how much a given stock price varied during the day. Chapter 3 presents the principal statistical measures of average and of dispersion for collections of data.

1-5 INFERENTIAL STATISTICS

Inferential statistics includes those techniques by which decisions about a statistical population can be made without all elements in the population having been observed or measured. Typically, the observed measurements in a random sample serve as the basis for statistical inference. In statistics a *population*, or universe, is the set of all elements that belong to a defined group. For example, all convenience markets in a given metropolitan area could be defined as the population of interest. A *sample* is a subset of elements taken from a defined population. A *random sample* is a sample that conforms to certain requirements such that probability concepts can be used in interpreting the sample results. For example, based on sales figures obtained from a random sample of convenience markets, we can estimate that the sales figures for all markets are within certain designated limits with a degree of confidence defined on the basis of applying probability concepts. The next section of this chapter describes the techniques by which a random sample can be obtained.

The summary values used to describe a sample are called *sample statistics*. In contrast, summary values for a population are called *population parameters.* Thus, the average weekly sales figure for a sample of convenience markets is a sample statistic, while the average sales figure for the population of convenience markets in the given metropolitan area of interest is a population parameter. In statistical inference, we typically wish to make some decision about a population parameter, based on the observed value of a sample statistic. Because such a decision is made under conditions of uncertainty, statistical inference always involves the application of probability concepts. For this reason, Chapters 4 through 6 are devoted to probability and probability distributions. The techniques covered in the remainder of this book are concerned with the application of these concepts.

The only circumstance in which probability concepts are not required is when all measurements or observations in the defined population are available. In this circumstance we might still be interested in the application of the techniques of descriptive statistics, but we would have no need for the techniques of statistical inference. When all the population measurements or observations are obtained, the process is called a *census.* Thus the national census carried out every 10 years in the United States involves an attempt to enumerate and describe all people in the country. Because of time and cost considerations, a complete census is not practical in many decision situations in business, and therefore the techniques of sampling and statistical inference are used.

1-6 METHODS OF SAMPLING

In general, there are three types of samples: convenience samples, judgment samples, and random samples. A *convenience sample* includes the most easily accessible measurements or observations, as implied by the word "convenience." For example, taking an opinion poll at a downtown intersection would be a convenience sample. A *judgment sample* is one in which the individual selecting the sample items uses experience as the basis for choosing the items to be included in the sample, with the objective being to make the sample as representative of the population as possible. An example is an accountant who chooses only certain records for a sample audit based on the judgment that these records are representative of the records in general. A *random sample* is a sampling procedure by which every element in the population has a known, and usually equal, chance of being chosen for inclusion in the sample.

Any of these three general types of samples could result in the selection of a representative sample of the population of interest, or the *target population.* However, only for a random sample can the *sampling error*, or variations due to sampling, be described on the basis of known probability concepts. The sampling variations associated with a convenience sample or a judgment sample cannot be described or anticipated on the basis of probability concepts, and therefore such sample results *cannot* be used as the basis for statistical inference.

Because the concepts of probability can only be applied to a random sample, such a sample is often also called a *probability sample.* In addition, because only a random sample can be used as the basis for statistical inference, it is often referred to as a *scientific sample.* There are in fact a number of specific methods, or sample designs, by which a random sample can be obtained. In the remainder of this section, we describe four such methods.

A *simple random sample* is one in which each item is selected entirely on the basis of chance. The result is that every element in the population has an equal chance of being included in the sample, and all possible samples of a given size n are equally likely to be selected. Chance selection does not imply arbitrary selection; rather, the elements are chosen on the basis of some randomizing procedure. By the preferred procedure, each element in the population is assigned a serial number, and the sample elements are then chosen by use of a *table of random numbers* or by use of a random-number generator on a computer. Table B-1 is an example of such a table. As an example of the use of a table of random numbers, suppose a population has 897 elements numbered 001 to 897 and we wish to take a sample of 50 elements. We would enter the table "blindly" by literally closing our eyes and pointing to a starting position. Then we would read the digits in groups of three, reading either to the right, left, downward, or upward, and choose the elements represented by those code numbers. Any unassigned code numbers would be ignored (000 and any value above 897 in our example). Also, we would ignore any code number that occurs a second time by chance. When we have selected 50 elements for the sample, we have completed the sample selection process. Although we simply refer to the samples in the remainder of the book as "random samples," the computational procedures presented are based on the assumption that the simple random-sampling method was used.

A *systematic sample* is one in which we select the sample elements from the population at a uniform interval of a listed order or at uniform points in time or distance. For example, we can take a 10 percent sample of all telephone subscribers listed in a directory by starting at a blind-choice point in the first 10 names and then choosing every 10th name thereafter. Technically, systematic sampling differs from simple random sampling in that each combination of elements does not have an equal chance of being selected. For example, if every 10th sequentially numbered element is chosen for a systematic sample, the elements numbered 233 and 235 could not both be included in the same sample. If systematic sampling is used, a particular concern is to avoid any periodic or cyclical factor that would lead to the inclusion of a systematic error in the sample results. For example, if every 10th house is at a corner location, a survey of households directed at the adequacy of street lighting would include a systematic bias if every 10th household were included in the survey. In this case, either all of the households included in the survey would be at a corner location or none of them would be at a corner location. When the order of listing of the population members can be assumed to be random in respect to the variable of interest (for example, wage rates of employees listed alphabetically), the results associated with systematic samples generally are analyzed with the same computational methods used with simple random samples.

A third type of sampling plan that results in a random sample being obtained is a *stratified sample.* In stratified sampling we classify the elements in the target population into separate groups, or strata, on the basis of characteristics associated with the variables being studied. The objective is that the several strata be different from one another in respect to the variable being studied but that the elements within a given stratum be similar to one another. After such classification, a simple random sample is taken from each stratum separately, and then the sample results are combined for analysis. For example, in a study of student attitude toward on-campus housing, if it is believed general differences exist between undergraduate and graduate students in this regard, a stratified sampling plan would be useful.

One obvious advantage of stratified sampling is that we can assure proportionate representation of each important subgroup in the population by taking the same percentage sample from each stratum. What is not so obvious is that by taking subsamples that are *not* proportionate, stratified sampling, as compared with simple random sampling, makes it possible to reduce overall sample size. For example, suppose 1,000 items in inventory are classified as low cost and 50 items classified as high cost. A 10 percent sample of the 1,000 low-cost items may be sufficient to estimate the average cost of these items at a required degree of confidence. (The statistical concept of "degree of confidence" is explained in Chapter 6.) But a 10 percent sample taken from just 50 items would probably be inadequate. Use of stratified sampling would make it possible to take a 10 percent sample of the large number of low-cost items while taking something like a 30 percent sample of the smaller number of high-cost items. Indeed, we could even take a 100 percent sample (census) of the high-cost items. In contrast, use of simple random sampling would