



STATISTICS FOR BUSINESS

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SCIENCE RESEARCH ASSOCIATES, INC.
Chicago, Palo Alto, Toronto Henley-on-Thames, Sydney
A Subsidiary of IBM

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Printed in the United States of America

Library of Congress Catalog Card Number: 73-75419

The distinction between a course in elementary statistics and one in elementary business statistics is principally a difference in emphasis rather than a difference in the basic theories and procedures which must be covered. Except for index numbers, time series analysis, and business forecasting, the topics discussed in business statistics are likely to be found in any statistics course at a comparable level of difficulty, whether intended for medical researchers, biologists, educators, industrial engineers, or any one of the many areas of study in which a knowledge of basic statistics is useful. However, while the theories and procedures are the same, there is a definite difference in the types of applications and the sources from which illustrative data are drawn. In this text, the examples used to develop an understanding of statistical theory and the problems given at the end of each chapter are drawn from the world of business and industry rather than from biological or medical research, education, or other nonbusiness areas.

Every effort has been made to make the text clear and readable by the student rather than impressive to those who already understand the material. Mathematical symbols are used where necessary but are omitted when the concept can be presented verbally with equal clarity and conciseness. The student who has a reasonable understanding of algebra will have no difficulty with the text; he should also be able to extract square roots and use tables of logarithms with reasonable facility. For students who are lacking in these basic skills, instructions and tables are provided in Appendixes G and H. The student is expected to assume responsibility for his own deficiencies and to take the necessary remedial action.

Preface

Chapter 2 contains a brief review of set theory and finite mathematics. Students who have already had courses in these areas will find this chapter easy. It is included here because it is essential that all students understand the basic principles and particularly the notation of finite mathematics. No knowledge of calculus is required to understand any procedures explained in this text. As usual in elementary texts in statistics, tables are provided for the area under the normal curve and any other computations which would require the use of calculus. The use of these tables is fully explained in the text.

The author makes no claim of originality except in the manner in which some of the basic procedures are explained. During the past twenty years, many good texts have been written and many different explanations have been tried. This book represents an attempt to select from these books and years of experience those concepts which are basic to an understanding of statistical methods and those examples and explanations which have been most satisfactory in teaching a fascinating but slightly difficult subject.

Statistics is best learned if the student never allows himself to get behind. For the most part, each chapter makes use of what has been explained previously. Sporadic study followed by long periods of rest will not be effective. The student is also warned that practice is essential. An understanding of the text and the instructor is not enough since they present material in a logical way and following carefully planned procedures. Independent problem solving allows the student to determine whether he understands the concept well enough to use it in situations which are slightly different from the examples given in class. Problems in the text or problems suggested by the instructor should, therefore, be used to develop the students' independence from detailed guidance.

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 Oliver & Boyd, Edinburgh, for permission to reprint Table III (as shown in Appendix D) and Table IV (as shown in Appendix E) from their book *Statistical Tables for Biological, Agricultural, and Medical Research*.

My grateful appreciation must also be expressed to Dr. Jean Gibbons and Mrs. Mary Curras, whose suggestions, criticisms, and editorial assistance have done much to improve the organization, content, and readability of the text. Also, my thanks to Professors Paul Paschke, Dale McFarlane, Joseph Monks, Eugene Abrassart, and William Browne, who contributed ideas for problems and examples. The editors of Science Research Associates, Inc., particularly Osborne Bethea, Jr., and Paul Kelly, have been exceptionally cooperative and helpful, and their suggestions, assistance, and encouragement are greatly appreciated. Thanks are also due to Clara Homyer and Shirley Exon, who typed the original draft and numerous revisions, and to Dorene Barnes, who typed the solutions manual. Lastly I would like to express my appreciation and dedicate this book to my wife, Ola May, whose encouragement helped me to survive the ordeal of writing and revising the manuscript and reading the criticisms of some reviewers who had vastly different ideas of the proper form and content of a basic statistics text.

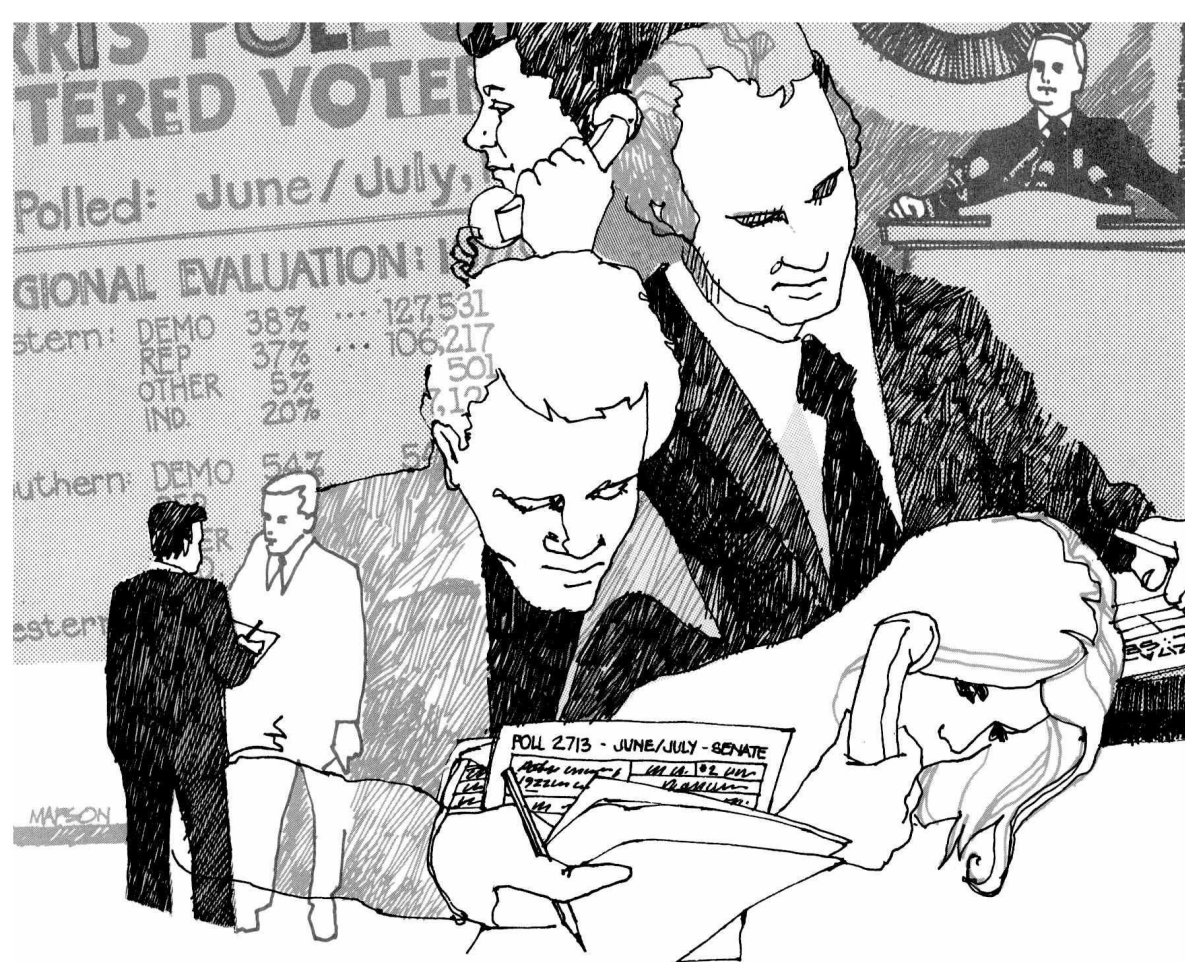
The author accepts the final responsibility for any errors which may remain, whether typographical or technical.

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1. Introduction to Business Statistics

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introduction to business statistics

1-1 Need for Quantitative Analysis

Business management involves a cycle of planning, implementing, controlling, and evaluating the operations of a firm. The success with which these operations are performed depends on the availability of valid, timely, and relevant information. Much of the required information comes from the analysis and interpretation of quantitative data.

The system for collecting and processing the data required for effective decision making is usually made up of a series of interrelated subsystems. Some of these subsystems are an essential part of the firm's normal accounting routines, while others involve the collection of external data or the further processing of internal records. *Business statistics* is the study of the procedures for collecting, analyzing, and interpreting quantitative data. These procedures may be applied to data from outside the firm, data from the internal records, or the results of surveys, special studies, or experiments conducted by the firm to obtain data which are not available elsewhere.

As a first step in the development of an information system, the owners and managers should define the firm's objectives to provide a guide for planning and a basis for the evaluation of results. Once the objectives have been defined, it is possible to determine what the firm must do well to ensure its success. These critical activities depend on the services which the firm renders and may include such things as a

strong dealer or sales organization, effective advertising, successful research and product development, safety and dependability, or carefully-controlled production or operating costs. The firm's information requirements depend largely on the activities which are critical to its success. The data collection and processing procedures, including statistical analyses, should ensure that adequate information is available at the time needed, in the amount needed, and to the persons who must make the decisions.

Although much of the data required for decision making is collected through the normal recording of financial transactions, traditional accounting reports were not intended for and do not provide sufficient information for effective management. Early bookkeeping systems were used to record the assets owned, the debts owed, and the equity of the proprietors in the firm. The revenues earned and the expenses incurred were recorded to reflect their effect on the owner equity and to provide a basis for the distribution of the profit or loss from operations. Over the past several hundred years, accountants have developed formal and logical procedures for recording financial transactions. Formerly, most accounting reports were summaries of historical data required for reporting earnings for income tax purposes or for reporting the firm's financial position to the owners, creditors, and regulatory agencies. In recent years, procedures and reports have been developed which have vastly increased the importance of accounting data in business management and control. Among the more important developments are responsibility accounting for better control of costs, program budgeting to provide a goal-oriented analysis of costs, and the use of historical data in the development of budgets and forecasts.

The use of nonaccounting analyses of business data is also increasing rapidly. One of the factors responsible for the increasing importance of business statistics is the recognition that data not collected by the accounting division are needed to keep managers informed of the economic, social, political, and competitive environment in which the firm must operate. These external data are required for long-range planning of product lines, production facilities, and labor and capital requirements, and to provide a basis for evaluating performance. In addition, statistical procedures can increase the value of data already available in the accounting division. For example, sales quotas for individual salesmen may be established through an analysis of sales records and the relationship of sales to various indicators of the sales potential of each district. Statistical techniques may also be used to determine the effectiveness of various advertising programs, to estimate the demand for a new product, to analyze seasonal variation in demand, and to study and forecast long-term trends.

The importance of quantitative analysis in decision making is due

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to a number of factors. Among the more important recent developments are: (1) the use of the computer to provide analyses which were not possible or economically feasible using older methods of record keeping and data processing; (2) the development of management information systems based on a study of the information requirements for effective management rather than the traditional accounting reports; (3) the development of new mathematical techniques such as linear programming; (4) the use of mathematical models and simulation to determine optimal solutions or study the effect of various decisions on the firm's objectives; and (5) the increasing use of statistical procedures to study the business environment, to provide a basis for forecasts and strategic planning, and to obtain additional value from data already available.

This text is primarily concerned with statistical procedures for analysis, summarization, presentation, and interpretation of quantitative data and the use of the resulting information in decision making, planning, and control of business operations. The data may be obtained from the accounting department or other internal records, from outside sources such as trade associations, competitors, private agencies, or governmental reports and documents. If the data needed do not exist, they may have to be collected through special studies, observations, or experiments.

1-2 Importance of Basic Business Statistics

Success in learning and applying business statistics is, to a large extent, determined by the student's personal motivation. For this reason, it seems desirable to explain the kinds of problems which can be solved once the basic procedures have been mastered.

Statistics is a fascinating field of study. It is filled with assumptions which may or may not be true, alternatives which may be correct but impracticable or only approximately correct but feasible, procedures which are based on approximations of unknown parameters, sampling techniques which may or may not be adequate, and predictions based on relationships which may or may not exist. Results often have an appearance of accuracy which may not be warranted by either the data or the procedures, and readers are often convinced when they should be skeptical. There are hundreds of ways in which the results may be misinterpreted. But, statistics provides a logical, well-planned attack on the problem of decision making in an uncertain world. Since decisions and forecasts must be made, it is essential that they be made as rationally as possible and that the approximate confidence in the correctness of the decision be known or determinable in advance.

A study of statistics provides a number of desirable outcomes. Some of these, with examples, are listed in the following paragraphs to help provide a feeling for what the course is about and to indicate its relevance to the business world.

1. Business statistics enlarges the student's vocabulary and improves his ability to read and understand business literature. For example, What do the following statements mean:

Retail sales for February were reported in an article at "seasonally adjusted annual rates."

The employees of General Motors have an "escalator clause" in their wage agreement to keep their "real wages" from slipping.

"A chi-square test was made to determine whether some characteristic of a company's product was normally distributed. The null hypothesis could not be rejected at the .05 level."

2. Business statistics improves the student's ability to collect data, to determine what has been found, and to present findings more effectively. Businessmen need to know important sources of data, to understand the preparation of questionnaires and summary tables and charts, and the use of averages and other devices for numerical description.
3. Business statistics helps provide estimates of the parameters of a statistical universe and indicates the reliability of the estimates made. A firm may want to find the average strength of a product to see if it will meet specifications set by a prospective customer, or to determine the sample size and the decision-making rule which will minimize the probability of accepting shipments which should be rejected or rejecting shipments which should be accepted.
4. Business statistics explains the theoretical basis and the procedures of statistical quality control. A production manager must decide whether a manufacturing process is under control. Statistical quality control procedures are widely used to maintain product quality and control the probability of looking for trouble when there is no trouble or not looking for the cause when there is trouble.
5. Business statistics makes it possible to compare two products or processes to determine whether the difference between samples is great enough to be considered significant; that is, not due to chance. If a new process or treatment gives better results than the old process or treatment, is the difference between samples sufficiently large that we may reasonably conclude that the new process is superior?
6. Statistical procedures make it possible to determine relationships between two or more variables and to make predictions based on these relationships. For example, it is possible to determine which variables (such as population, spendable income, retail sales, or

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automobile registrations) are most closely related to a company's sales, and to use these readily-available data to estimate the sales potential for each sales district.

7. Business statistics provides an understanding of *index numbers*. For example, if employees of Company X had an average weekly take-home pay of \$256.00 per week when the Consumer Price Index for their city was 112.5, what weekly take-home pay is required to provide the same buying power if the Consumer Price Index is now 138.2? If inventory valuations are known for some point in the fiscal year for each of the past ten years, has the physical volume of goods in inventory increased or decreased; that is, how can inventory control procedures be evaluated and what has been the effect of price level variation on the value of inventory on hand?
8. Business statistics helps make better forecasts of coming events. A firm must forecast such things as production, inventory needs, personnel requirements, working capital requirements, and cash flow. Statistics provides explicit and logical procedures for using past records and the current economic outlook to arrive at useful estimates of the immediate and the long-range future. Past records can be used to find the seasonal pattern in sales or production, and steps can be taken to reduce the severity of seasonal fluctuation with its accompanying problems of excessive overtime in peak seasons, layoffs in slack seasons, and less than full utilization of fixed assets.
9. Business statistics helps develop an orderly procedure for using probability to determine the course of action which has the highest expected monetary value or the greatest expected utility when several alternatives are possible.
10. Business statistics improves the use of scarce resources by reducing the cost of obtaining the information used in making a decision. Every item tested, every interview obtained, or every piece of data gathered costs money. It is possible to spend more for data than the data are worth. Perfect information is seldom available and even less often necessary. Statistics enables the businessman to determine the amount of data required to provide any specific reliability of decision making rules. This eliminates informational overkill, which is costly and fruitless.

1-3 Statistics and Mathematics

Statistics is primarily concerned with quantitative data, yet it is not considered a course in mathematics even though it is often taught by

mathematicians. Business statistics is primarily concerned with the application of statistical techniques to business problems. Most introductory business statistics books require little mathematics beyond that typically expected of high school graduates. This course is considered among the harder undergraduate business courses, not because of the difficulty of the mathematics involved but because of the number of concepts encountered in a single course.

This text contains all the mathematics prerequisite^{前置条件} for understanding business statistics, with the exception of basic algebra. It assumes: (1) the ability to work with symbols, (2) the ability to use simple algebraic equations, (3) the ability to use logarithms with reasonable skill, and (4) the ability to find the square root of a number. Students who cannot handle the latter two techniques must correct these deficiencies before proceeding to the next chapter. Appendixes G and H contain instructions and required tables.

1-4 Basic Procedures in Problem Solving

Most statistical investigations follow a fairly standard procedure. When the analyst omits one of the essential steps, he may find that his results are invalid, unreliable, needlessly expensive, or useless for the problem at hand. While no two persons would outline the steps in exactly the same way, a flowchart generally takes the form shown in Figure 1-1. Since these procedures are essentially the same for any scientific method of investigation, they are explained without elaborate comment.

The first step is to *get the problem clearly in mind*. This means that the researcher must know what the problem is, what decisions are to be made or what hypotheses are to be tested, the time period to be covered, the definition and nature of the population to be studied, the terms in which the data are to be collected and reported, and the limits of the problem.

The second step is to *determine what has already been done* in this area of study. This survey of related studies helps to avoid unnecessary repetition, may reveal procedures which have been successfully used by others, or suggest other procedures, and may provide additional insights to the problem. After the investigation of related studies, it is often necessary to revise, restate, or alter the original problem, or it may even be advisable to abandon the project. It may also be necessary to prepare cost estimates and obtain approval for expenditure of funds; approval is ordinarily based on a comparison of expected costs and expected benefits.

Once the final problems have been clearly defined and delimited, the third step is to *determine exactly what data are necessary* to answer

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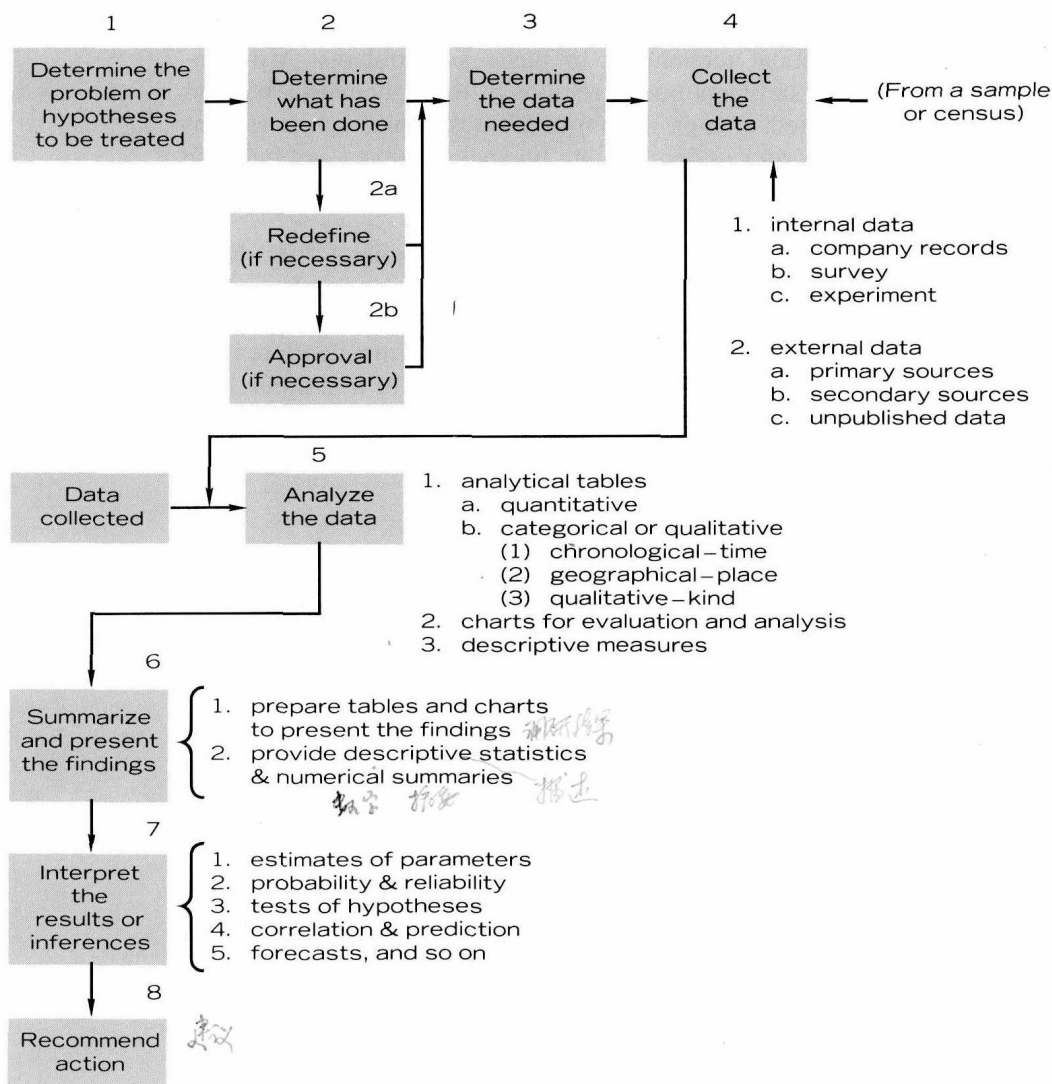


FIGURE 1-1. Steps in a Statistical Investigation

the questions, make the estimates, or test the hypotheses which have been defined. Forms for tables, graphs, and statistical summaries, and procedures for hypothesis testing should be planned before the data are collected. Students new to statistics sometimes begin a study by preparing a questionnaire and collecting data. They then attempt to see what decisions can be made on the basis of the "facts" now available.

This is an ineffective and unscientific approach and often leads to useless data.

The fourth step is to *collect the data*. Typically, one of three situations exists: (1) the data are available within the firm, (2) the data are available from some source outside the firm, or (3) the data do not exist and must be gathered by the analyst. In any case, the data must be collected and tabulated so that they may be understood and interpreted.

After the data have been collected and tabulated, the next step is to *analyze the data*. The researcher prepares analytical tables and charts to discover the meaning of the data and the significant relationships.

The sixth step is to *summarize the data*. The researcher must decide on the most effective way to present his findings to others who may be interested in the study. If unexpected relationships appear, additional tables may be needed. If the amount of data is not great, the findings may be presented verbally, but usually a more compact method of presentation is required. The three principal ways of summarizing data are: (1) tabular presentation, (2) graphic or pictorial presentation, and (3) numerical description or characterization.

If the data reflect the results of a sample rather than a complete enumeration of the population, it may be desirable to make inferences about the population on the basis of the partial and incomplete data obtained in the sample. These procedures, which *interpret the findings* and provide guidelines for the decision or *recommended action* are among the major concerns of business statistics. Chapters 5, 6, 7, and 8 describe procedures for making estimates and inferences or testing hypotheses, and Chapter 9 describes procedures for making estimates of one characteristic on the basis of other related and more easily-measured characteristics. Chapters 10, 11, and 12, respectively, explain some special techniques in the use of index numbers, time series analyses, and decision tables in the decision making process.

1-5 Sources of Business Data

Internal Data

A firm's own records provide the most important source of management data. This is especially true if the firm has a management information system which uses a computer. In this case, the data are recorded at the level of the lowest unit of information and can be sorted and printed in almost any conceivable manner. For example, the sales record for each invoice line item may show the invoice number, name and location of customer, date, salesman or sales district, item sold, cost, selling price, terms, and other relevant information. Sales analyses can be made