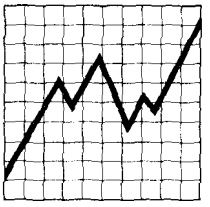

CONTENTS

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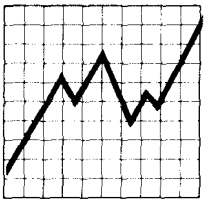

INTRODUCTION

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Business executives and managers are decision makers. Administrators of hospitals, colleges, and other organizations are decision makers. Decisions are based on information, and much of this information is in the form of numbers—numbers which are frequently called *statistics* or *statistical data*. Thus, statistics *are* numbers. On the other hand, statistics *is* a field of study. Students working toward decision-making careers take one or more courses in statistics. I'll start by discussing what statistics *are*, then discuss what statistics *is*, and finally return to decision making.

1.1 STATISTICS ARE

The word *statistics*, which is derived from the word *state*, entered the English vocabulary in the eighteenth century. It was used then, and still is used, to mean one or more sets of numerical data on population, taxes, wealth, exports, imports, crop production, and other items of interest to state officials. Today we use the "set of numerical data" meaning when we refer to baseball statistics, stock market statistics, production statistics, labor statistics, and so on. In the plural, then, statistics, or statistical data, are numbers—not abstract numbers such as those in a table of square roots, but concrete numbers such as inventory counts, measurements, dollar prices and dollar sales, interest rates, and average hourly wage rates.

Statistics: *a group of numerical data*

1.2 STATISTICS IS

Statistics: *a field of study*

Statistics *is* a field of study. The main parts of this field of study are descriptive statistics, probability, decision analysis, and statistical inference.

Descriptive Statistics

The Bureau of the Census has described the ages of people in the United States population as shown in Table 1.1. The table does not show the ages of every person. Instead, it provides an understandable summary description of the ages of many millions of people. Now look at the numbers in the last column—the medians. The top number means that in 1950, 50 percent of the people in the population were under, and 50 percent were over, 30.2 years of age. The 50-50 meaning applies to all the medians. Run your eye down the column and note that the median age first declined, and then rose. The medians in Table 1.1 provide a very condensed summary description of changes in ages.

The median is one descriptive statistic. There are others.

The Bureau of the Census—a major statistical arm of the United States government—projects a continuing rise in the median age for the remainder of the century. Population and other data compiled by the Bureau are used extensively by decision makers. For example, in deciding how to allocate funds for research and development, drug manufacturers are influenced by the growing numbers of older people. On the other hand, my college—which followed a policy of expansion in the 1960s and early

TABLE 1.1
POPULATION OF THE UNITED STATES BY AGE GROUP, 1950–1977
(In thousands of persons except for median age)

Year	Total all ages	Age group, years										Median age, years
		Under 5	5–13	14–17	18–21	22–24	25–34	35–44	45–54	55–64	65 and over	
1950	152,271	16,410	22,423	8,444	8,947	7,129	24,036	21,637	17,453	13,396	12,397	30.2
1960	180,671	20,341	32,965	11,219	9,555	6,573	22,919	24,221	20,578	15,625	16,675	29.4
1970	204,878	17,148	36,636	15,910	14,707	9,980	25,294	23,142	23,310	18,664	20,087	27.9
1975	213,540	15,882	33,440	16,934	16,484	11,120	30,918	22,815	23,768	19,774	22,405	28.8
1976	215,142	15,343	32,962	16,893	16,767	11,396	32,049	23,080	23,641	20,065	22,947	29.0
1977	216,817	15,236	32,227	16,783	16,956	11,646	33,149	23,543	23,389	20,395	23,494	29.4

Source: Adapted from the *Statistical Abstract of the United States, 1978.*

50,000 is zero—it has never occurred—not the 90 percent stated by the businessperson.

Probability, as a subject area, develops rules for working with relative frequency or degree-of-belief probabilities. These rules show how to use one or more known probabilities to obtain an unknown but desired probability. As an example, suppose there is a 0.9 probability—a 90 percent chance—that a fire detector will function if there is a fire. Suppose also that the functioning of one detector does not depend on whether another detector functions. If two detectors are installed, you would expect the probability that at least one (that is, one or the other, or both) will function to be greater than 0.9. Probability rules that we shall develop tell us that this is so and that the desired probability is 0.99. Thus, there is a 99 percent chance that at least one of two detectors will function if there is a fire.

As this simple example shows, probability itself (the numbers and the rules) has useful applications. Moreover, probability is the foundation for the more technical subjects in statistics—decision analysis and statistical inference.

Statistical Decision Analysis

Many of us would decide to invest $1000 in a business which, in our opinion, has a 99 percent chance of returning $10,000 to us during the coming year. Few, if any, would make the same decision if the chance of the $10,000 gain is only 1 percent. Similarly, a clothing store owner may decide to order 500 women's dresses for the spring season because she believes there is a high chance (say, 95 percent) of selling all, or most, of the dresses. The owner knows that her profit might be doubled if 1000 dresses were ordered and sold, but dismisses this opportunity for higher profit because the chance of obtaining it is too small (say, 10 percent). Statistical decision analysis is concerned with making a decision when alternative courses of action (e.g., how many dresses to order) exist but the profits and the probabilities associated with the actions vary. Generally, the higher the potential profit, the lower the probability of achieving this profit. Decision analysis will be introduced after your study of probability.

Population, Sample, and Statistical Inference

A statistical inference is a statement made about a *population* but based upon information about a *random sample* selected from the population. The terms *population* and *random sample* have very specific meanings in statistics.

Populations In everyday language, the word *population* means *all* the people in a specific area. We use this meaning when we speak of the population of New York City. In statistics, the word population has a broader meaning. All the accounts in a bank make up a population of bank accounts.

prove absolutely that smoking causes the disease. Researchers suspect tarry substances in tobacco may be a cause. Nevertheless, the Surgeon General made the decision to require the warning—and tobacco companies decided to market and advertise low-tar cigarettes.

Item: In 1975, Social Security tax deducted from paychecks was at the rate of 5.85 percent on earnings up to a "wage base" of $14,100. In 1977, Congress decided to raise the tax. Statistical data played an important role in this decision. Higher taxes were needed because of increases in the number and the proportion of persons eligible to receive Social Security payments. Moreover, payments to eligible persons rise when prices rise; so price data affected the decision. In 1980, the tax rate was 6.13 percent on earnings up to $25,900. The rate is scheduled to rise through 1990. Furthermore, the "wage base" will increase when the average wage level increases. You can expect to pay higher Social Security taxes as time goes on.

The two items just cited relate mainly to decisions in government. A hint of the range of business decision problems involving statistics is provided by the following list.

Problems in which statistics are, and statistics is, needed

1. Selecting locations for new stores, restaurants, warehouses, fire stations
2. Deciding whether to continue or cancel a new television series
3. Forecasting whether an economic recession is imminent
4. Negotiating a labor contract
5. Determining what to charge (the premium) for fire, casualty, life, health, and other insurances
6. Setting up airline schedules
7. Establishing sales quotas for regional sales territories
8. Deciding how long a replacement warranty to offer on a product
9. Selecting the appropriate media in which to advertise a product
10. Planning production schedules and raw-material purchases for the next 3 months
11. Deciding which stocks to buy or sell, and when
12. Deciding the quantity of goods to be carried in inventory, and when to reorder
13. Selecting new management trainees
14. Determining the quality of manufactured camera film when the testing destroys the product
15. Deciding whether or not to market a new product
16. Deciding whether to publish a textbook and, if so, how many copies to print
17. Deciding to start a new business
18. Determining what factors promote employee morale and motivation

Each of the listed items relates to making decisions. Statistical data also are obtained and used by advocates to serve their purposes. By an advocate I mean a person who argues for or defends a cause, proposal, or course of action. In this meaning, Ralph Nader is a consumer advocate. Labor and management representatives become advocates when labor contracts are nego-

Advocates use statistics.

tiated. To see advocacy involving statistics at work, let's sit in on a contract negotiation. The negotiators are Fran (for management) and Bob (for the union).

Fran: Bob, we follow the consumer price index, just as you do. Prices have been rising, and we go along with you for about a thirty-cent-an-hour increase—maybe a little more—to compensate for increased living costs. But we can't go along with your demand for ten cents for what you call sharing in increased productivity.

Bob: Just look at the company's annual reports. Sales are up twenty percent over last year, and the number of employees is just about the same; so sales per worker are up. That's what we mean by increased productivity. Our people do the work, and we demand our fair share of that increase.

Fran: Come on, Bob, I just agreed that we would offer you an increase to compensate for increased living costs—and now you turn the coin over. All prices have increased, including the price of our product. The sales increase you quote is due to price increases. It doesn't mean that your people are working harder and making more product per worker.

Bob: Even allowing for price increases, productivity still has increased.

Fran: That's not true, but I guess we are not going to be able to get together on how to compute productivity statistics. Maybe we could agree on having an impartial consultant prepare some figures we might agree on.

Bob: I'll speak to my people and get back to you on that.

Fran: What about this matter of increased hazard on the job? Our figures show fewer accidents this year than last.

Bob: That's right, but if you figure the number of accidents per 1000 labor-hours worked, it's higher this year than it was last year.

Fran: There is nothing unusual about that. The change was small, and that rate always fluctuates a little from year to year.

Bob: I know that, Fran, but look at this chart for the last ten years. The rate does fluctuate, but the important fact is that the trend has been definitely upward. It's about time the company either paid more attention to safety or compensated us for increased hazard on the job.

We have listened to the discussion long enough to observe advocacy involving statistics in action in one business context. But advocacy is widespread. At one time or another most of us become advocates. If you want to be an effective advocate, prepare yourself by obtaining relevant statistical data.

I should mention that statistics—numerical information—may be used to mislead or deceive. Of course, nonnumerical information also may be used for this purpose. However, probably because people feel that numbers should be somehow "correct," misleading by numbers is considered to be a greater sin than misleading by words. A person may feel so strongly about misleading uses of numbers that he or she comes to distrust—and

disregard—all statistics. That's burying one's head in the sand. We should be as critical of statistical information as we are of nonnumerical information. We should neither trust all statistics nor distrust all statistics. The point is well stated by W. A. Wallis and H. V. Roberts in their book *Statistics, a New Approach* (The Free Press, Glencoe, Ill., 1956, p. 17). They write that "he who trusts statistics indiscriminately will often be duped unnecessarily. But he who distrusts statistics indiscriminately will often be ignorant unnecessarily."

1.4 LOOKING AHEAD

This book has been written for students—you—rather than for professional statisticians. I will not ask you to learn mathematical proofs or do complicated algebra. Simple algebra is all you will need to understand and use the symbols and formulas found in the book. You will often be doing arithmetic and taking square roots. A hand calculator will be extremely helpful.

When we start a new topic, I will explain what is involved, then give one or more examples. Frequently, I will then ask you to do an exercise to help you fix the topic in your mind. The answer is given with the exercise so that you will not have to search for it. After a related group of topics has been discussed, a set of homework problems is provided. The answers to half of the homework problems are given at the end of the book. Additionally, a set of review problems covering a whole chapter appears at the end of each chapter except this one. The review problems will help you prepare for examinations.

This is an applied book. The examples, exercises, and problems are drawn from a wide variety of applications of statistics. Applications help you learn and give you a reason for wanting to learn. Look for applications in your surroundings—the more you find, the more you will learn about statistics.

1.5 PROBLEMS

1. Distinguish between statistics plural and statistics singular.
2. What are the main sections of the field of study called statistics?
3. What is a probability?
4. With what type of decision is statistical decision analysis concerned?
5. In the statistical sense, what is a population?
6. What is a simple random sample?
7. What is a statistical inference?

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