GRAPHIC STATISTICS IN MANAGEMENT

BY

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PREFACE

A beginner in the field of statistics will find many able books upon the subject of both statistics and graphics into which he delves with amazement or trepidation at the apparent complexity of the method and technique.

This is due, in part, to the fact that most of the books on statistics have been written from a theoretical point of view. There has been little effort to coordinate statistical practice and graphic usage.

In this book an effort has been made to treat the principles of statistical and graphical practice cohesively—to show their interdependence and relation—in order that the student or business man may find an exposition of the subject sufficiently complete to enable him to understand what others have done or may do and to establish within his own business a statistical and graphic practice of his own.

The principles of graphic practice have been covered first and so arranged that their varying elements may be determined and the proper graphic form selected. Next, the principles of statistical activity have been discussed—not in their entirety—but broadly enough to acquaint the business man or student with the requirements he is apt to need. And last, both statistical and graphical practices have been considered as they apply to the different phases of business or the individual business.

The subject as a whole has been approached from the graphic viewpoint because the assimilation of statistics is rendered that much easier through this approach.

That statistical practice and graphic control are occupying a more important part in the business field than ever before is evident. Dean Donham, of the Harvard School of Business Administration, recently said, "The whole field of business statistics is practically new and the possibilities of this approach to problems of executive control are little appreciated. In my judgment, statistical methods will, within a comparatively few years, develop to a point where the progressive business man attributes as much importance to the subject as he does to accounting. In some ways, the subject of statistics is even more vital, because it is only through a statistical approach that the business man may hope to correlate his own with general business conditions."

It is hoped that this book will help to develop the subject of statistics in the business field by giving to the business man or student an understandable presentation from the business point of view.

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This book is presented with no claims as to the originality of the material. It contains information gleaned from all available sources and presented in a manner which should enable the business man to acquaint himself with the standard forms and practices both in collecting and tabulating statistics and also in selecting and constructing graphs.

To those who have been kind enough to allow the reproduction of illustrations, I wish collectively to express my thanks, and to those who have directly or indirectly assisted in the gathering of material and its presentation I am most grateful; but more especially to Mr. Percival White and Mr. Walter S. Hayward whose untiring interest and assistance have been responsible in a large measure for the final development of this book.

W. H. S.

Cambridge, Mass.,
June, 1924.

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PART I

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GRAPHIC STATISTICS IN MANAGEMENT

CHAPTER I

INTRODUCTION

The use by the business man of statistical records graphically presented is not new. But only recently has the value of graphic presentation been widely realized as forming a peculiarly concise and informative manner in which to record business activity.

To some executives and in certain departments, accounting records have been of substantial assistance. But as generally used they are records only of what has happened and offer comparatively little information as to the present situation and even less as to future trends. Also, because accounting records are exclusively in monetary terms, their use is restricted.

Business men have consequently come to realize that statistical recording of practically all phases of business activity is necessary, and they have at the same time sought to develop an improved technique of statistical control and graphic presentation. This volume at the start discusses these improved methods which are predominately graphic in character, and after setting forth the technique of graphic presentation, its practical use as an aid to management upon specific problems is discussed.

Statistical analyses both within the individual business and as disclosing the effects of general economic conditions are as yet in the formative stage. Records do not extend back far enough to admit of anything more than approximate accuracy in analyzing trends. In the past the government has been the great collector of statistics and today one of the important developments in the statistical field is the work of commercial organizations which are digesting and popularizing all available figures. The time is undoubtedly coming when it will be possible for business men to obtain fundamental statistics from a common source through a daily or weekly service, which may enable them to interpret economic conditions both in general and as related to their business and locality.

But before such a service can be effectively used it will be necessary

that business men be trained so that they are able to interpret statistical tables and graphs intelligently.

Methods of Presenting Facts.—Quantitative facts may be presented in three ways:

1. As a plain statement of fact. For example, the average monthly sales of a retail store in percentage of its yearly sales are: January 7.4, February 6.1, March 8.1, April 8.4, May 8.5, June 8.3, July 6, August 5.6, September 7.3, October 10.2, November 10.1, and December 14 per cent.

Such a statement, however explicit, does not convey the facts clearly to the mind.

2. It may be a statistical table:

Month	Percentage of Total Yearly Sales
January	7.4
February	6.1
March	8.1
April	8.4
May	8.5
June	8.3
July	6.0
August	5.6
September	7.3
October	10.2
November	10.1
December	14.0
Total	100.0

This statistical presentation is clearer. The figures and their relation, their rise and fall, may be visualized more easily. There is a definite orderly succession of facts.

3. It may be a graph. Graphic presentation tells the story almost at a glance (see Fig. 1). The decrease and increase of sales by months are plainly indicated. The peaks and depressions stand out at once.

The graph cannot, of course, take the place of the numerical series of facts in tabulated form. It supplements it. Figure 1, to render the greatest significance, should be accompanied by the statistical table already given.

Values in Graphic Presentation.—Graphic presentation is being increasingly resorted to because of its special merits. In addition to the relative ease with which material so presented may be grasped, there are the following values to be emphasized:

The graph is valuable for purposes of comparing several sets of facts. Graphs accentuate differences in numerical facts from one time period to another in a way which tables fail to disclose.

Graphs make easier the study of the trend or tendency in a group of numerical facts or events over a period of time.

On the other hand, graphs do not usually admit of the fine degree of accuracy peculiar to the numerical statement.
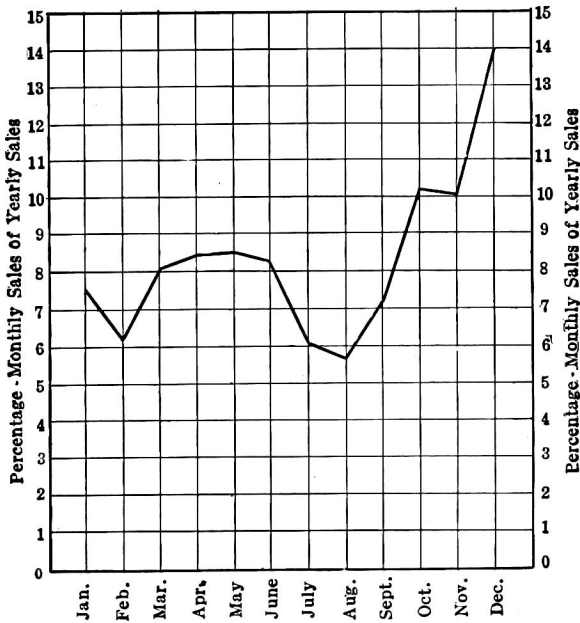

Fig. 1.—A graph.

Nor are they effectively used where there are a great many complex facts which would require interlacing curves to give the truest picture.

In short, the proper use of the graph is for the presentation of numerical data which can be reduced to relatively simple form.

CHAPTER II

STATISTICAL DATA

Graphs are simply statistics presented in a specialized manner. Accordingly, before discussing graphs at length, it will be necessary to set forth the elements of statistical method. This chapter will be devoted to the discussion of statistical data and the methods of obtaining them. The next chapter will treat of statistical presentation.

There are certain fundamental principles which should be carefully considered and put into operation wherever any statistical plan is in operation. These are few and simple:

1. The first step is to determine the statistical problem. What, in short, do you want to know? Primarily, the collection and tabulation of statistics should contemplate the maximum of information with a minimum of expense, time, and effort.

2. The second step is to determine the unit in which the information is to be expressed.

3. The third problem concerns the sources, their number, their nature, degree of accuracy, etc. If statistics are not already available, care must be taken in advance to procure these statistics by the methods hereinafter set forth.

4. The fourth principle has to do with the proper observance of the rules of statistical presentation.

The Problem or Objective.—The primary consideration in gathering statistics should be to set a definite objective and to collect and tabulate statistics to that end, rather than to collect statistics generally with the view of their possible effect upon an uncertain and nebulous goal. Once the broad plan has been agreed upon, the subsequent activity in collection and classification is clarified to a considerable degree.

The practical application of the necessity of a plan may be illustrated by a consideration of the study of sales statistics. The avenues of approach to such statistics are obviously varied; the final result always the same. Hence the plan becomes of especial importance, since the objective is a maximum of information with a minimum of expense and effort.

Suppose that the final result desired is the total sales over a period. These statistics are available at once in the controlling sales account, but while that account tells the final story, it tells little else.

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Is it desirable, then, to obtain the sales statistics from other sources, and at the same time with more effort obtain a larger number of related statistical facts?

Is it desirable to determine sales upon the basis of orders and cancellations when and as received, or upon the basis of the billing of each shipment?

Is it desirable to determine the sales by commodities, by salesmen, by mail, by distributors, or by some predetermined unit such as the dollar, the pound, ton, etc.?

What, finally, is the exact purpose to which the statistics are to be put? What is their value after they have been obtained, and does the cost of obtaining them justify the result? Is it possible to obtain a given result in the simplest way, and at the same time obtain in addition subsidiary statistics of practically equal value? In other words, how much varied statistical information can be obtained with a minimum of statistical work and expense?

These questions lead into problems of statistical compilation which must be decided with reference to each individual case, but the answers to just such questions will spell the success or failure of any statistical effort.

The situation existing in a large corporation, the statistical efforts of which have never been thought out or coordinated, exhibits the waste arising from such unanswered questions. A large force of clerks is maintained to secure monthly statistical summaries of sales activities. These summaries are segregated in unrelated but overlapping groups. In addition, individual clerks, located elsewhere, maintain statistical records of an entirely different character designed to cover local requirements of individual departments. Lastly, individual statistics are kept by isolated individuals for the requirements of their particular jobs. Further, in certain branch offices individual customers' records are maintained, all of which, in whole or in part, are obtainable in another form elsewhere. Perhaps the most astounding feature of all is that such statistics are taken from the billing record rather than from the order record.

In the aggregate, the time, labor, and expense of maintaining such records in the form in which they are kept would more than pay for the maintenance of a well-organized statistical department, furnishing the statistics not only more promptly but unquestionably more completely and over a greater range of requirements.

The great trouble in this case is that the statistical problem has never been considered as a whole, nor have the piecemeal statistical efforts been coordinated and applied to all the interested phases of this business. The statistics have just grown, with the result that hardly an executive finds the statistics of value. In many cases they are so out of date when

they reach the hands of someone able to use them that they are past history and not suitable for current usage.

Lack of a definite knowledge of the statistical problem has done more to hinder the growth of statistical development in business than any other one thing.

Such a state of affairs seems strange when the business man's insistence on accurately balanced accounts is taken into consideration. Perhaps the fact that accounting deals with actual money, while other facts are less tangible, is responsible for the difference. The business man fails to see that well-planned, carefully tabulated statistical information places in his hands one of the keys of business success.

The Statistical Unit.—Assuming an adequate knowledge of the statistical problem, the next consideration is the unit in which the solution is to be expressed. Is it to be money, things, small units, large units, percentages, ratios, or what?

The numerical facts relating to every problem for statistical analysis must be reduced to some common denominator. The larger the statistical problem the wider the range of different statistical facts, most of which, however, can be reduced to some statistical common denominator. Preferably this should be a unit of fixed measure. Ordinarily the dollar is used.

The unit of measurement should be clearly defined, and if it is a variable unit, some measure of correction, if any, indicated. In the last analysis, statistics are valuable only in their comparative significance, and variable-unit statistics where possible should be correlated to determine their real relation.

Using the dollar as a unit of measurement is sometimes attended with difficulties. Dollar statistics indicated tremendous increases and decreases under the conditions that existed during the World War. The volume of commodities, however, showed little or no variation. Under such periods, plans based on dollar statistics should be checked against actual performance.

Another example is afforded by the comparison of imports and exports between periods of exact equality in the exchange units with others of considerable inequality. The unit of measurement, if possible, should not be subject to variation.

King says:

It is not only desirable but *strictly essential* that the unit be accurately and unmistakably defined, and that the same unit be used in each of the periods or places between which it is intended to make comparison.

Business is always dealing in dollars, pounds, tons, packages, kilowatts, etc. All these statistical units are susceptible of reduction to a com-

mon denominator, even though it be in the form of a coefficient. When reduced to such a common denominator, they become comparable.

Methods and Sources of Business Statistics.—Statistics within the individual company, obtained from records, reports, etc., are usually termed "internal" statistics, as opposed to those secured from sources outside the company, or "external" statistics. Internal statistics are ordinarily comparatively simple to obtain and to check for accuracy and uniformity (see Fig. 2). The scope of the problem usually is of considerable assistance in determining how and where the statistics shall be obtained, in many cases narrowing the field to one possible source.
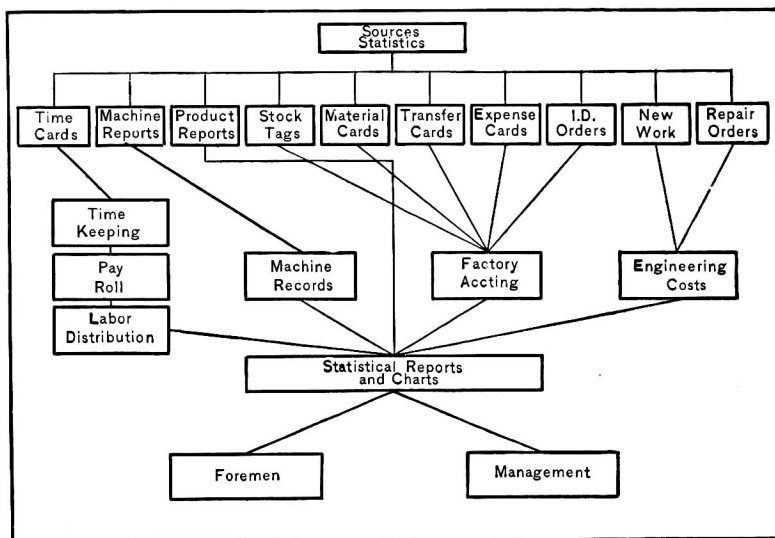

FIG. 2.—Chart showing sources of internal statistics (*Goodyear Tire & Rubber Co.*).

Where there is more than one source, the problem is more complicated, and, as mentioned before, the timeliness, the ease of obtaining, and the general conditions will determine which method to adopt.

In using statistics, whether external or internal, the object should be to obtain and to use only statistics of primary origin, in so far as this is possible. From the internal point of view this is simple, but the problem of tracing external statistics back to their sources is not always easy. The individual using statistics must, for his own protection, ascertain whether the statistics being used are primary or secondary, and govern his conclusions accordingly.

Internal Statistics.—Internal statistics should always be obtained at their points of origin. It is only in this way that they reflect accurately what has immediately preceded, and predict what is likely to follow in subsequent activity.

Suppose, for example, that A wishes to collect certain statistics about the volume of business he is doing. He has decided that he wishes to obtain them by commodities and in units, which, in this particular case, are 100-pound bags, his primary purpose being to obtain facts as to the actual daily volume of business he is doing on each commodity.

This is a relatively simple problem, because there are but two records which give this information: first, orders received, and second, orders shipped.

Of the two records the latter is considered more accurate, since it represents the actual money value in materials which leave his hands each day, and in hundreds of cases this record is seized upon as being not only the most accurate but the quickest available record. As a matter of fact, it rarely serves as a satisfactory indicator of current business. In the first place, it is remote. The time value has been lost entirely, because what is shipped one day may represent orders received a week or 10 weeks ago.

In the second place, the individual order may have lost its identity. It may be a partial shipment, billing of which has been deferred. It gives no indication of the business in the field as the salesmen, representatives, wholesalers, or customers find it.

There is really but one logical source from which to obtain statistics which give the pulse beat of current business as it varies from day to day, month to month, season to season, and with different localities. This is through the individual salesman's or customer's orders. By obtaining statistics of this nature it is possible to tabulate by unit, by section of the country, by salesmen, by product, by mail orders, by cancellation, and in many other ways, and an *immediate picture* of the business as it is from day to day can be secured. The statistical result is definite, immediate, concrete—not indefinite, delayed, and abstract.

The methods by which the internal type of statistics is obtained are rarely so simple as just outlined, but in few cases are the statistics desired so different as to make this method of obtaining them impracticable.

External Statistics.—Obtaining external statistics represents a far different and more complex problem than the securing of internal facts. As far as fundamental statistics are concerned, the individual company must be content to secure its data from the government and from other reliable sources. There are, however, several methods by which the company can gather those external statistics which are regarded as necessary to the success of the problem in hand.

Personal Investigation.—Personal investigation is adaptable to certain intensive studies. The individual investigator examines innumerable cases within the scope of his inquiry, obtaining, in so far as possible,

accurate detailed answers to previously selected questions, and extending the scope of the investigation as he proceeds.

That the results may be totally unbiased, personal investigation requires a type of mind which is able to separate its personal conclusions from the conclusions pointed out by the facts.

The length of time required to obtain statistics by personal investigation and the expenses incurred during the course of securing answers in sufficient quantity to prevent appreciable error in many cases prohibit its use.

While personal investigation is used to some extent in all phases of business, it is chiefly directed towards obtaining market data. For example, one particular company made an investigation of this character to determine the consumption of soap per family. The investigator visited family after family in certain previously selected racial and social communities, and was able, after computation, to apply certain constant conclusions to other geographical units of determinable character. By this method it was possible to obtain what might be termed the "soap saturation" point of any community.

Such an investigation gave to the concern making it an accurate and indispensable knowledge of the amount of soap business of various kinds which might be expected from any given community. By coordination with the sales and advertising activities, plans were worked out which resulted in an increased sales volume with reduced expenses for those activities.

The Questionnaire Method.—The successful use of the questionnaire in assembling data and the value of the final statistical result depend largely upon the form of the questionnaire. This method contemplates the submission to a representative group of individuals of a series of questions so worded and arranged that they may be answered definitely. The best type of answer is a simple "Yes" or "No," but numerical answers can be obtained in some cases, notably by trade associations in securing data from members.

Questions should always be phrased so that they do not indicate the desired answer nor prevent, for any reason, an expression of the real opinion of the person asked. Furthermore, questions should be as few in number as is compatible with the salient points to be covered. All questions which might prove interesting but are in no way conclusive should be omitted.

As in all statistical work, accuracy is essential. The real value of this method is destroyed if, through improperly selected questions, the answers are rendered vague, inconclusive, or untruthful. Whenever the questionnaire method is used, the greatest variable, human nature, must be borne constantly in mind in framing and arranging the questions.

The questionnaire method increases in accuracy as the questionnaire itself increases in simplicity. It is, however, scarcely an advantageous method unless the persons to whom it is sent are interested in the subject and are willing to take the time and trouble to consider and weigh their answers carefully.

Enumerators.—The use of enumerators is familiar to all of us from the taking of the United States Census. While it is too expensive to employ enumerators in the majority of private enterprises, it is possible to use salesmen or other employees to make statistical reports. It is also customary in some companies to employ special investigators when the need arises.

When salesmen are called upon to make reports of a statistical nature, it is important to prepare the subject matter under consideration for their use. Otherwise a series of reports will result which will be so unreliable as to be practically worthless. The general disrepute in which salesmen's statistics are held in many cases is due not to the salesman but to the improper methods of acquainting him with the statistical plan, and the omission of a proper form upon which he may report his findings in a clear, concise, and unmistakable way.

The crux of the enumerator method, as well as of the questionnaire method, lies in framing the questions to be answered, although in the former method the personality and ability of the enumerator is of considerable value.

King gives the following rules to cover the drawing up of questions for use in questionnaires and by investigators. He says the questions should be:

1. Comparatively few in number.
2. Answerable by "Yes" or "No" or a number.
3. Simple enough to be readily understood.
4. Such as will be answered without bias.
5. Not unnecessarily inquisitorial.
6. As far as possible corroboratory.
7. Such as directly and unmistakably cover the point of information desired.

Estimates.—Estimates of a statistical character are ordinarily made by some method of sampling or testing. The object is to secure a record of a sufficiently large and representative portion of the subject under consideration to justify drawing conclusions for the whole group.

The proportion of the group to be taken as the basis of the estimate cannot be arbitrarily decided upon until the range of variation is found. The wider the range of variation, the greater the number of representative instances that must be under observation. Conversely, the narrower

the range, the fewer the instances it is necessary to tabulate in order to make the estimate representative.

Generally speaking, however, unless the extent of the investigation is large, and the individual judgment good, the results are not satisfactory. Where, on the other hand, the inquiry is extensive and the judgment of the answerers fair, the results are surprisingly correct. The rule of inertia of large numbers tends always to offset individual errors, as explained in the following chapter.

Secondary Statistics and Their Use.—The secondary type of statistical practice is based upon the use of figures gathered by others, either in whole or in part. Such statistics should not be used without careful analysis, both of the figures themselves and also of the sources from which they came. The art of propaganda has been developed to such a degree in recent years that it is possible to find almost any point of view proved correct by statistical means. It is only when an analysis is made of the sources and methods of compilation of the data that the unreliable character of many of these studies is brought to light.

In general, King sums up the standards by which the value of secondary statistics may be judged as:

1. From what sources the figures have been derived.
2. The definitions of the units, including instructions to the enumerators.
3. The purpose for which the data were originally collected.
4. The methods used in collecting them.
5. The degree of accuracy of the figures.