

CONTRIBUTIONS OF STATISTICS

I to the III
SCIENCE OF MANAGEMENT

by

Walter A. Shewhart
Bell Telephone Laboratories

Paper to be presented to the Management
Division of The American Society of
Mechanical Engineers, November 30, 1948



SCIENCE

Prediction

Important distinction between science and other forms of organized knowledge is the concern of science with the possibility of accurate prediction.

Scientific Method

Hypothesis
Experiment (measurement)
Test of hypothesis

Examples Prediction

1. Measurement of a physical constant - Birge
Slide #25376
2. Measurement of contact resistance - Slide #25408
3. Law: $pv = rt$
4. Past, present, future data
Slide #25438

STATISTICS

Royal Statistical Society - When the Royal Statistical Society of London was founded more than a century ago, its stated objective was: "to collect, arrange, digest, and publish facts illustrating the condition and prosperity of society in its material, social, and moral relations".

Statisticians have been called the show-girls of the market place since they live by their figures alone.

One of the best modern introductions to the theory of statistics states that "by statistical methods we mean methods specially adapted to the elucidation of quantitative data affected by a multiplicity of causes". An Introduction to the Theory of Statistics, Yule and Kendall.

Repetitive Act

- Slide #21612 - 144 observations - table
- 30536 - " " plotted
- 25405 - nonrandom arrangements
- 25407
- 30568 - frequency curve
- 30528 - plotted with lines
- 30669 - Birge data -
- 23040 - Act of control
- 20472 - Circular nature of production process

MANAGEMENT

Definition - "Management is the art and science of preparing, organizing and directing human effort applied to control the forces and to utilize the materials of nature for the benefit of man". ASME TRANSACTIONS, 1913.

- Slide 30579 - Mathematics, pure, applied science, etc.
- " 30569 - Factors within and beyond control.
- 16000 - History of control.
- 30586 - 1789, 1870, 1924.
- 33171 - Time Study Operation
- 33170 - " " Suboperation
- 30562 - Typical organization chart.
- 30699 - A typical production process.

Abstract

The important distinction between science and other forms of organized knowledge is the concern of science with the possibility of accurate prediction. Moreover, it is today generally recognized that all predictions, including those of the elite sciences like physics and chemistry, must be placed on a probability basis. Thus in theoretical physics we do not attempt to predict that an electron or other particle of modern physics will be in a certain element of volume $dx dy dz$ at a specified time t but instead we predict the probability p of its being there. Likewise it is generally agreed that the only operationally or experimentally verifiable meaning of such prediction is in terms of the statistical interpretation of probability. Hence it is that accurate statistical prediction may be considered a fundamental objective of any science.

The scientific method of tackling problems involves the alternate use of inductive and deductive inferences. In other words, it is customary to start with the conception of an hypothesis, the consequences of which can be rigorously deduced with the aid of mathematics. These deductions suggest the results that might be expected if certain experiments are performed. Hence the customary second step in scientific method is one of experimentation. The third step is that of comparing the observed data with the theoretical deductions in order to test the hypothesis.

The use of scientific method in this sense is largely made to rest upon the ability to experiment and to repeat an experiment at will again and again as may be done

in physics and chemistry. Since, however, repetition of experiments in this sense would not always give the same results, it is necessary to make allowance for this fact by introducing statistical hypotheses, the statistical design of experiments, and the statistical test of hypotheses. Statistical method from this modern viewpoint is not something different from scientific method but rather an improved scientific method to allow for the statistical character of any repetitive act, such as that of experimentation.

Many of the decisions that must be made by management include predictions in fields where experimentation is not possible. For example, many decisions depend upon predictions with respect to future economic and social conditions; other decisions depend upon predictions with respect to the changes in consumer wants and such natural factors as the weather. In contrast, many of the operations under the control of management, such as research, development, design, production, inspection, purchasing, and sales are subject to experimentation.

There are those who maintain that scientific method is not applicable in those fields where experimentation is not possible. Whether one agrees with this decision or not, it is significant perhaps to note that up until recent years the contribution of statistics to the solution of managerial problems has been judged almost solely upon the contributions of statisticians in the social and economic aspects of business where in many instances there may be a question as to whether or not accurate predictions are possible. It is also significant that perhaps the greatest progress in determining whether

or not accurate valid prediction is possible has been made during the recent years in the field of the natural sciences. Moreover, in these fields it is now definitely established that the use of the scientific method modified to take account of the statistical nature of the repetitive act of experimentation has made important contributions.

In the field of scientific management, as in any other scientific field, two questions naturally present themselves, namely:

- 1) Under what specific conditions is it possible to make accurate predictions in the statistical or probability sense?
- 2) Under conditions where such predictions can be made, how does one proceed? Within the past twenty-five years, statisticians have made important progress in answering such questions. The object of the present discussion is to survey very briefly some of these recent contributions, particularly as they apply to research, including the design of experiment.

Walter A. Shewhart

W. A. SHEWHART'S COLLECTION

