THE FUTURE OF

STATISTICS IN ~~INDUSTRY~~ MASS PRODUCTION

by

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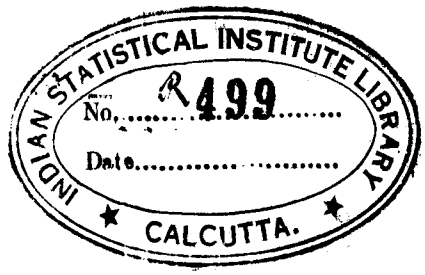

Notes for informal talk at luncheon meeting of the Institute of Mathematical Statistics at Detroit, Michigan, December 27, 1938

WHY THE TOPIC?

Years ago I followed with some fervor the cartoons, Bringing Up Father. One in particular I well remember. It pictured Jiggs (Father) coming into his office and finding the office boy seated in the boss's chair with his feet on the boss's desk. The tenor of Jiggs' remarks was to the effect that the boy should quit his loafing and find something useful to do. The boy's response was a pained expression and the question: "Do I have to find something to do and do it too?" A few months ago President Camp put me in somewhat the position of the boy in the cartoon by asking me in effect if I would find something to say and say it too at this luncheon meeting.

That was months ago. December 27th seemed a long way off and I promised. Little did I realize what I was doing until a few days ago, when I started the necessary preliminaries to keeping my promise. I had had in the back of my head for some time a rather hazy idea of saying something about the progress made by industrial statisticians during the past decade in applying statistical theory to engineering and manufacturing problems. This topic seemed quite appropriate in that active cooperation along this line was started by several engineering and scientific groups just about ten years ago. However, the longer I pondered the past, the stronger I felt that our meeting to-

day is not nearly so much an occasion for looking backward as it is for looking forward. We as a society haven't arrived: we have just started. Only by keeping "eyes front", can we do bigger things in the future. But, by keeping eyes front, we can do bigger things than some of us only a few years ago would have even dared to dream of doing. Let me, therefore, sketch briefly what to me seems to be the call for an extension of the role of statistics.

STATISTICAL METHOD IN ACQUISITION OF KNOWLEDGE

If the outlook on the role of statistics is to be extended, it is well to consider from what to what. In this section, we shall consider "from what". Let me say at the very beginning, however, that I appreciate full well the danger in trying to contrast the old with the new: the border line is always fuzzy enough to provide grounds for more than one interpretation.

To start, let us start with recall the contrast between taking a trip for pleasure and taking one for the sole purpose of getting from one place to another. In one case, we set out to know and enjoy something of what is to be known; to broaden our experience of the world as it is. In the other case, we set out to get to some definite place. Now, in the field of science, we act in two ways quite similar to ~~those just noted.~~ Here we may either seek new experience or knowledge primarily for its own sake, or we may seek

knowledge for some specific use. We often describe the two activities by the terms pure and applied.

It seems to me that the statistician's eyes have usually been fixed in the past on the acquisition of knowledge as knowledge. Oh, of course, every statistician hopes that the knowledge he acquires may be useful in many ways but he is often not concerned with the acquisition of knowledge for some specific use. For example, you may have noted how often authors of statistical texts talk of studying, discovering, and measuring phenomena such as the study of variation, the study of populations, the discovery of statistical laws, and the measurement of trends or the effects of a multiplicity of unknown causes of variability. Does not the emphasis appear to be on study, discovery, and measurement to the end of a better understanding of our surroundings?

Of course, the outlook of statisticians has been changing. Whereas a few years ago, the statistician was contented to help discover reproducible characteristics of observed phenomena in the data handed to him, today he insists on having a finger in deciding what and how data are to be taken so that the discovery of predictable phenomena will be conducted in the most efficient way. Nevertheless, if I am not mistaken, the statistician of today in his emphasis on the design of experiment, like the statistician of yesterday, usually thinks of what he is doing as a con-

tribution to research primarily as a means of acquiring knowledge about social and material phenomena. Statisticians have usually thought of themselves as helping to make possible valid predictions of what will take place tomorrow assuming that the underlying cause system remains in pretty much the same state as it has in the past. Except perhaps in isolated instances such as the control of quality, statisticians have not set out to see what they could do by tinkering with this underlying cause system in a way to attain a definite and wanted end.

Go to any library and you will find shelf on shelf filled with the products of the statistician. He has measured the demand for this and that economic good and measured the interrelations between them. He has measured production costs, output, and a multiplicity of other phenomena. He has measured the variability produced by many different kinds of chance system of causes. He has charted the trends of population and he has charted the index of countless numbers of different kinds of quantities.

Let us assume for the sake of argument that all such effort taken together represents an outstanding contribution to knowledge. Let us grant that this vast storehouse of knowledge may be of use in many different ways, some few of which may be known today and many of which no one has yet dreamed of. Let us grant that the statistician's contributions to basic long range research for

knowledge as knowledge should continue.

Now let us think for a few minutes about the fellow whose success in life depends upon accomplishing some specific end and who, like many of us, does not know enough yet to be able to accomplish that end. What that fellow wants is not just knowledge as knowledge. He wants the specific knowledge that will help him to get where he wants to go. Should we direct him to that vast storehouse of empirical knowledge which the statistician has provided? If we do, I am afraid that we have failed to do for him the great service which I am confident we as statisticians can do if we choose. Let us therefore consider the role of statistics for this man with a specific job.

STATISTICAL METHOD IN ACQUISITION OF KNOWLEDGE FOR SOME SPECIFIC USE

I suggest that we think for a few moments about the role that the statistician can play in making this world a better place in which to live. I suggest that we think about two things: a), human wants and b) the physical possibilities of satisfying these human wants. Let us think about two kinds of people that play a very important part in this picture; one, the producer of economic goods that go to satisfy human wants and the other the consumer whose wants are to be satisfied in the consumption of the goods. Let us fix our attention on a fundamental problem, namely, that of making the best use of means available for

satisfying human wants through the agency of fabricated goods. How can the statistician best contribute to the solution of this problem?

I imagine that some of you are saying to yourselves: Well, that problem can be solved in completeness only through a complete understanding of what is knowable about the physical world and about the human world. On this point, there would be no argument so far as I am concerned. That is the high road to the attainment of our goal. However, I assume that none of us hope to see the day when such knowledge will be available and in the meantime, some of us must travel the low road of trying to make the best use of our daily efforts in solving the problem of satisfying most effectively specific human wants for economic goods.

What Characterizes the Problem?

1. An outstanding characteristic of the mass production of goods to satisfy human wants is the necessity of setting up and living within a tolerance range for each specified quality characteristic. Then if you contract to live within such a range and fail, you may lose your shirt. Hence it pays to know how to make valid predictions within tolerance limits.

2. The mass production of goods to satisfy human wants involves three distinct steps:

I. The specification of the quality of the thing wanted,
II. The production of things designed to satisfy the specification,
III. The inspection of the things produced to see if they meet the specification.

usually either

Sometimes these steps are carried out by different companies ~~or~~ ~~If carried out within the same company, they are in almost every case carried out~~ by different departments in the same company ~~parts of that organization~~. Oftentimes a specification is made the basis of a contract between the consumer and producer. The process of taking these steps often involves the cooperation of physicists, chemists, engineers, ~~designers, manufacturers,~~ sales agents, purchasing agents, economists, and lawyers. To this group actually taking part in the production process there must be added those representing the consumer. Very few of all these people have ever had any technical training in statistics or probability.

3. I have shown elsewhere that there are many statistical problems in each of the three steps. To illustrate I need recall ~~here~~ only the following question that arises in the third step, ~~namely,~~ inspection. How large a sample shall be taken? If it had not been for this kind of question, I doubt that statisticians would have as yet been able to make themselves felt in industry.

The alert statistician may, if given the opportunity, find many ways in which to be of service in each of the three steps. The important point to note, however, is that the statistician must not consider the three steps, specification, production, and inspection as independent if he is to make his greatest contribution. Instead he must see them as correlated in such a way that the nature of the statistical problem in one step depends upon what is being done in the other two. ~~To~~ ~~give one~~ cite one example, ~~it has been shown elsewhere that~~ if the sta-

tistician plays his full role in helping to modify the three steps so as to attain statistical control, the necessity of sampling is almost eliminated from the third step. We need not as it were, live forever with the question: How large a sample? We can reduce the need for sampling.

The situation here is quite analogous to the efficient design of experiment in that the statistician helps design definite operational techniques used in each of the three steps.

4. The most useful concept of a standard of quality is not something that can be reduced to writing. Such a standard of quality is not a written finality but a dynamic process involving these three steps, specification, production, and inspection. It is not merely an imprisonment of the past in the specification but also the unfolding of the future.

If the intent of the standard of quality is to imply the most efficient use of materials and the minimum cost of production, it is necessary to consider that the standard changes as the information obtained in taking a succession of such steps reveals the need for such change. In fact, it is only in the process of mass production, where it is possible to retrace again and again the succession of three steps, that one can hope to minimize the cost of inspection and the cost of rejection, and to make the most efficient use of materials and parts.

5. Enough has perhaps been said to show that the statistician must not only find his problem and do it too but he also has a great big job of selling a very large number of

people with many different backgrounds.

What Does the Statistician on the Low Road Need to Know?

1. Needless to say, every statistician should be familiar with the statistical methods of research used on the high road leading to the acquisition of knowledge as knowledge. This should include training in distribution theory and its use in the analysis of variance and design of experiment. To this training certain other information should be added along lines indicated by the following suggestions.

2. The statistician needs to understand the difference between a tolerance range and the fiducial range of modern statistics. He needs to understand the difference between acquiring knowledge that will enable him to set up and live within a specified tolerance range and the problem of acquiring knowledge that will enable him simply to interpret the statistical significance of observed variability.

3. He needs to see the statistical characteristics of the problem of specifying a chance variable in order that he may be in a position to develop the techniques of specifying operationally verifiable quality characteristics. In this connection he needs to know much that no one knows today. This is particularly true if he is to specify the desired order in a random sequence as it is necessary to do if he is to specify in an operationally definite way what we mean by homogeneous quality.

4. There is much for him to learn about the theory and practice of the statistical control of quality in production that is not customarily taught. He must have this information

if he is to do his share in detecting and eliminating assignable causes of variability.

5. Perhaps above everything else he needs to know how to make operationally verifiable statements involving statistical terms; he needs to be able to distinguish between statements that are practically verifiable and those that are only theoretically verifiable. He needs to know how to distinguish between the verifiability of a prediction and that of a judgment based upon specified evidence. This necessitates an understanding of knowledge as an everchanging relation between evidence, prediction, and degree of belief. Such an understanding is of particular importance as a background for judging whether or not product is of standard quality in the sense defined above.

What the Statistician Must Do

Let me close with a few suggestions as to what we as statisticians must do in the future if we are to maximize our contribution to the production of goods to satisfy human wants.

1. Our first big job is to get a broad view of just what role we are to play in this vast program of making the best use of limited means of satisfying human wants. Our job is to see our role not as those who know nothing about statistics see it but to see it as they would see it if in their present capacities they knew statistical theory. We must not be content to wait for some one who knows nothing about statistics to find us something to do. Our hair may turn grey in the process. We must instead find our job and do it too. We must see our job not as one of measuring what the little demons of chance are forever doing when left to themselves. Instead we must take

The future of statistics in mass production lies not so much in solving the problems put to him as in taking a hand in designing and managing the coordinate step. —

Spec.
prod.
insp.

Lies not so much in getting eighty thousand more statisticians in industry at once as in creating a statistically minded new generation

Lawyers
business men
Engineers
physicists
chemists
Consuming public.

a hand in controlling the demons.

2) But how are we to do our job? As statisticians we must get across to the leaders of the future - business men, lawyers, purchasing agents, sales agents, engineers, economists, physicists, chemists, and statesmen - that the statistician can do more than measure the effects of complex systems of causes; in many instances, he can devise means of controlling them. Something of the same idea should be gotten across to those who will constitute the Johnny Q Public of tomorrow. We need to present a new gospel - statistics as a way of doing and not simply as a way of measuring.

3) The statistician of the future must not simply measure demand; he must help change that demand by showing for example how to close up on tolerances.

4) He must not be content with measuring production costs; he must help decrease production costs.

5) He must not be content simply to measure the variability of a complex system of causes; he must take an active part in devising techniques that make it possible to control that variability.

This very briefly is my picture of the statistician of the future and what he must do if he is to live up to his opportunity.

THE FUTURE OF STATISTICS IN INDUSTRY, AS FOR SCIENCE, IS ONE OF STUDY, MEASUREMENT, AND RESEARCH ON THE EFFECTS OF UNKNOWN OR CHANCE CAUSES AS THEY ARE TODAY. IT SHOULD INCLUDE DEVELOPMENT OF TECHNIQUES FOR CONTROLLING THE EFFECTS OF CHANCE CAUSES IN THE BEST WAY TO SATISFY SPECIFIC HUMAN NEEDS

a Future of Statistics should not simply consist
in solving the problems put to the statistician.
b should include