Management Services: A Magazine of Planning, Systems, and Controls

Volume 1 | Number 2 Article 6

5-1964

# Decision Making: Art - or Science

Clark Sloat

Arthur B. Toan Jr.

# DECISION MAKING
# ART—OR SCIENCE?

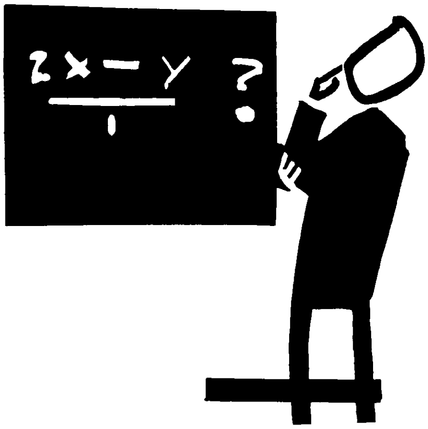
*Concluding their discussion of mathematical management, the authors explain how high-speed data handling can reduce the role of intuition in some types of business problem solving.*

*by Clark Sloat and*
*Arthur B. Toan, Jr.*
*Price Waterhouse & Co.*

*In the first of two articles on the scientific method in management decision making, Mr. Sloat and Mr. Toan outlined some mathematical techniques that can be helpful in business problem solving; described how one of them, linear programing, might be used in deciding which plant should supply which dealer to minimize costs; and listed problems whose answers can be improved by the application of operations research methods. Emphasizing that most of the recent progress toward making management more scientific would have been impossible without the electronic computer, they now explain its role in developing data for mathematical formulation, solving the formulas, and facilitating control.*

WHAT IS the relationship between mathematical management—if we can use this term to describe the general process of management assisted by mathematics—and high-speed data handling?

The grand concept of business is that business consists of a large number of complicated interrelationships capable of being expressed in terms of mathematical formulas. Business data processing under this concept consists of two parts: (1) the housekeeping part, i.e., paying employees, paying vendors, billing customers, collecting cash, etc., and (2) the data producing part, i.e., providing the information necessary for the decision-making control cycle. The second part of this job (the production of data for decision making and control) can be thought of as providing the raw material which these formulas need to work. You can, we imagine, easily visualize pouring into a computer a large amount of data about sales, costs, expenses, etc.—factual data taken from the company's records—plus a lot of additional data—about company plans, market conditions, price trends, competitor actions, general economics, and some factors for the probability that certain events will occur and certain actions will take place. Once within the computer, these data would be operated upon in accordance with the rules laid down by the mathematical formulas developed to represent reality. The result would provide a basis for re-




***The process of developing important relationships among pieces of scientific data is partly intuitive and partly mathematical. As the quantity of data increases, the proportion that is mathematical increases tremendously. That is why so much use is made of high-speed computational equipment. The same situation exists with business data, even though the answers may be less exact and as hard or harder to to find. In this respect, the computer holds an important potential.***

viewing the past or taking action on the present or planning for the future.

To do this in anything like its complete form would require, even in smaller companies, a fantastic amount of computing capacity. It has not been and, in all probability, never will be done in anything like its ultimate detail.

Nevertheless, as a concept, the grand concept is absolutely valid. Express the business relationships as mathematical formulas; feed in data about past or future facts and probabilities; calculate results and choose a course of action; determine actual results and recalculate course of action. So far, this concept has been applied only to a limited area of a business—to inventories, to sales effort allocation, to determining work force needs, etc.

Leaving aside the grand concept, then, how is a high-speed computing system used? It is used in four ways:

1. To solve the formulas when the time required for their solution by other means is excessive

2. To develop some of the data required to be put into the formulas in the first place

3. To routinize some lower-level decisions

4. To facilitate the process of control

The problem of allocating producing to plants, warehouses and customers, previously cited, produced a fairly awesome number of complex calculations even with the relatively few facts and relationships being considered. Quite obviously, in a real-life situation, the number of calculations could be extended tremendously by the addition of plants, customers or other factors.

In an oil refinery with which we are familiar, 350 formulas with 500 unknowns are to be used to determine how the refinery should be scheduled to turn what quantity of what crudes into what quantity of what finished products to obtain the maximum dollar profit from the operations. This computation will take, it is estimated, a couple of hours on a very large, very fast computer. This, we hasten to add, is considered to be a relatively simple refinery with many of the more sophisticated time-consuming calculations intentionally omitted. Obviously, then, electronic machines can be useful in solving the formulas.


**Computers can make it eminently practical to routinize a large number of operating decisions . . .**

They can also be useful in producing or processing the data necessary for the formulas—by providing the following opportunities which might otherwise not be available:

1. To break down the data in a more detailed fashion than was previously economical

2. To produce the data more quickly and/or more frequently

3. To explore the data to determine the kinds of relationships which actually do exist

The availability of high-speed electronic equipment can, it can easily be seen, make it possible to analyze data in a more detailed manner. It is obviously more practical to think of manipulating figures into more detailed patterns when the cost of doing so decreases. A more detailed analysis of transportation movements, or of the manner in which materials are used, or of the sources and causes of scrap, for example, can provide valuable data for the mathematical models.

That high-speed equipment can make data available more quickly and/or frequently can also, we be-

Freed of paperwork by machines that report control data on an exception basis, management can devote its time to more productive activities.

lieve, be accepted as a general rule even though numerous exceptions can be cited.

About the final use, we should perhaps be more explicit by citing an example falling outside business. A scientist trying to find out how and why something works often conducts a large number of experiments. These experiments produce results to which we shall once again tag the term "data." To find out what these data mean, the scientist will try to arrange them according to all sorts of different patterns to see what kinds and degrees of relationships exist. When the correlation is low or nonexistent, the scientist will probably be unimpressed, unless he is trying to eliminate factors. But when the correlation is high, the scientist will know he has found a significant factor. This process of developing important relationships is partly intuitive and partly mathematical. As the quantity of data increases, the proportion which is mathematical increases tremendously. That is why so much use is made of high-speed computational facilities in our scientific and research world.

### *Automatic decisions*

The same situation exists with business data although, admittedly, we often do not think of it in this manner. It is true that we can seek out relationships and degrees of correlation in much the same manner that the scientist does and that even though the answers may be less exact and as hard or harder to find, what we do find can provide an important competitive edge. In this respect, the high-speed computer holds an important potential. Important work has been and is being done, for example, to determine the value obtained from varying the amounts of sales effort—or from various amounts and types of advertising, just to cite two examples.

Computers can make it eminently practical to routinize a large number of operating decisions.

It can easily be demonstrated that many business actions which we dignify by the use of the term "decisions" amount to very little more than the application of a set of carefully prescribed rules to individual business events. Checking to see (1) that a credit limit has not been exceeded, (2) that the time has come to follow up a delinquent debtor, (3) that the inventory on hand has fallen below the reorder point are well-known illustrations of this point.

Many of the rules that are applied are capable of expression in mathematical terms—dollars of credit, number of days' supply on hand, number of units, percentage of change from last or normal, etc. A computer, tackling the decision-making problem, could compare these mathematically stated rules with the facts of the case. It could, using its skill and facility, accept or reject the customer's order on the basis of its acceptability from a credit standpoint, decide which customers to follow up, decide when and how much to order, etc., or write out for human intervention the relatively small proportion of the situations in which really high-grade human judgment is needed.

A computer could, therefore, apply the rules of mathematical management in a virtually automatic manner to many lower-level operating decisions.

Computers likewise have a contribution to make to the process of control. Perhaps this contribution can be expressed most succinctly by expanding that well-known "catch phrase"—"If you can't measure it, you can't control it"—into—"If you can't measure and compare it, you can't control it."

The essence of control is comparison—comparison with past performance, or with a standard, or with a norm, or with a statistical deviation from a norm—to cite a few examples. Once again, this means that if the events can be stated in numerical terms, and if they can be measured and if the standards of comparison can likewise be stated in numerical terms, a real opportunity exists to use computing equipment to make these comparisons, i.e., to exercise control.

This generally means two things which should be fairly obvious: (1) that the machine can pass over those items falling within acceptable limits, and (2) that the comparisons made can be somewhere between rather and highly sophisticated in their nature. What may not be quite as obvious is that in the process you can also free a lot of the time of managers which is now spent by them in merely identifying problems and their causes for the more productive work of curing the problems and reducing the chance of their recurrence in the future.

However, to leave the impression that high-speed computing equipment is essential in even a majority of cases would be wrong. Very useful results can be obtained in a large proportion of the cases either without it or with only its occasional use. These results are useful because of the following:

1. Valuable intuitive ideas will result merely from having some smart people look at a situation or a problem area.

2. Often the calculations are not so extensive that they cannot be made by less powerful equipment.

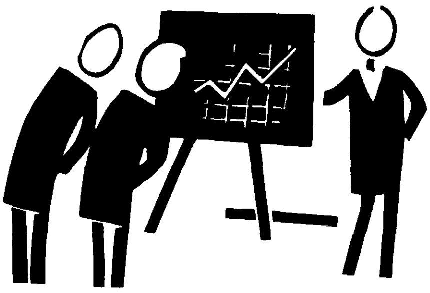
3. It is often practical to omit certain refinements, and thereby to simplify the calculations, without sacrificing too much of the value which could be obtained from the ultimate solution.

4. Many times it is feasible to solve the problem by the occasional use of high-speed equipment and to portray the results in tables, charts or graphs which can be used in day-to-day operations.

Thus, to use some terms we used before, the correlation between mathematical management and high-speed electronic equipment varies all the way from unnecessary to nice to essential.

All of this is not, of course, quite as simple as it may possibly have been made to sound. Limitations on the usefulness of these methods do exist; we merely made the deliberate choice not to clutter up the consideration of the basic ideas with a lot of qualifications, but instead to treat these limitations en masse.

Some of the limitations represent just as severe limitations on the application of intuitive judgment. We



**The computer's answers can be portrayed in tables, charts, or graphs.**

should, however, think about them briefly because of the apparently unavoidable human characteristic of imputing a high degree of precision to almost everything which is expressed in mathematical terms—whether this is deserved or not.

The limitations are these:

1. The inability of people and machines to ferret out of the mass of business data which is available a precise statement of the relationships and interrelationships which exist. This problem, it might be added, is in no way helped by the fact that many of these relationships conflict in such a way as to obscure rather than to clarify real causes and effects.

2. The great difficulty of predicting with a high degree of accuracy the impact of some new event—military, economic or technological, or even a hit TV show—on your or your competitor's position.

3. The absence of a great deal of important information about past actions and events—information which was not kept because it was considered of only transient significance. We can often tell, for example, what happened but not the conditions which existed nor the reason for the action and not the consequences of taking the action or of not taking it. To choose a very simple, yet key bit of information which is rarely available—how often were we out of stock and what were the consequences of this?

4. The basic absence of information about the past, present and future acts of our competitors and of the business world in general.

5. The fact that in many instances we are concerned with marginal or incremental values and costs—with the net marginal gain from stocking more or less inventory, with the net marginal gain from changing the staffing of a toolroom, with the net marginal gain from changing the maintenance policy, etc. This information is not normally available at present—or at least, not without many approximations and/or a great deal of digging. As a matter of fact, many thoughtful accountants believe that a new or at least drastically modified concept of accounting and record keeping may be necessary before this information does become readily available on a reliable and routine basis.

6. The difficulty in placing a concrete value on some of the intangibles—customer goodwill, good employee morale, community reputation, etc.—which form an important consideration in many business decisions.

7. The need to develop additional mathematical techniques which are capable of coping with some of the problems and relationships of business. A number of mathematical methods now in use, strange as it may seem, did not exist ten to twenty years ago but were created to fill the need. Still more are waiting to be developed.

8. The fact that computers themselves with all their power and abilities can be and often are physically and economically outstripped by the size and complexity of business problems and relationships.

This sounds like a fairly imposing


**It is difficult to place a concrete value on some of the intangibles—such as customer goodwill, employee morale, community reputation—that form an important consideration in many business decisions.**

set of limitations and it is. But imposing as they are, they do not offset the present and potential power of OR as a valuable aid to management.

One question which is often asked by business executives is "How do we organize to use these methods?" From the previously cited list of problems you can undoubtedly recognize many problems which would be susceptible to solution by OR techniques. The question, therefore, of what to undertake seems to be the simple one. The problem of how to undertake it is not quite so easy.

First, you must have available a competent technician. These people are not easy to find. Your degree of success in OR technique will, however, depend upon the quality of the personnel employed in the effort. The operations researcher to be effective requires a rather broad knowledge of many different scientific techniques. He must know probability statistics, differential equations, calculus, etc., as well as many of the concepts which have been developed in the physical sciences. He must know when he cannot use a mathematical expression for a normal distribution or a Poisson distribution, when to use certain mathematical theorems, when to use linear programing. when to use game theory, as well as all of the other various tools which have become available.

After you have a technician, it is necessary to supplement his efforts with those of people who know and understand business operations. This may be contradictory to the statement of many of the well-known operations researchers, but it has been our experience that solutions to problems are obtained far more quickly and in a far more practical manner if the team studying the problem includes someone who is thoroughly acquainted with the operation under study. No benefit can be obtained from any technique unless a practical, usable solution is derived. Therefore, it is necessary to avoid a completely ivory tower approach, and put emphasis upon the practicability of results. On the other hand, you should not completely discourage a certain amount of research beyond the requirements of the immediate problem, for in the longer view one can expect a payoff for such freedom as a result of the basic stimulation which your OR man receives under such conditions.

No one can provide a nonmathematician with sufficient knowledge of the techniques in a short time to enable him to carry out the technical parts of the studies. The important thing for the nontechnician is to know that mathematical techniques are available for stating some of the complex relationships which exist in business today. It is important for the nontechnician also to know that with some study and effort he can generally check the logic expressed in these mathematical relationships, so that he is able to provide the technician with the benefit of his knowledge of the intricacies of business relationships and to apply common sense checks to the results.

We are just on the threshold in the development and use of these techniques. We have, however, learned enough even at this point to know that despite their limitations, they can be highly beneficial and often lead into relatively new concepts in the solutions to problems. We do not know enough about applications at the present time to fully define all types of problems which may be susceptible to solution through use of these methods. We do know that the area of aplicability is very broad.

We do know that the methods and techniques of science can contribute to the art of business management.