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TOP MANAGEMENT DECISION AND SIMULATION PROCESSES

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Summary

This is a talk delivered at the National Convention of the American Institute of Industrial Engineers, June 12, 1958, in Los Angeles, California.

It is an exposition of some of the general problems facing one in the construction of a simulation process, and of some of the ideas that can be used to treat these problems.

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I would like to talk today about simulation processes in general and a Top Management Decision Game in particular. This Top Management Decision Game is a kind of "do-it-yourself" kit for producing executives. It is hoped that this game will produce executives who are trustworthy, loyal, helpful, friendly, courteous, kind, obedient, cheerful, thrifty, brave, clean, and reverent. Furthermore, I am told that while playing the game, the players receive beneficial radiation, and that the very pencils they chew are impregnated with vitamins.

The first question that should be asked is: Why are people interested these days in management training programs, and why do we have simulation processes?

Probably the principal reason we do have simulation processes is that various organizations are willing to pay for them—and pay fairly good prices. After all, there is a law of supply and demand in the scientific world as well as elsewhere. Naturally, the next question is: Why are people willing to pay fancy prices for the construction of these games and for the privilege of participating in them?

The answer is obvious—there must be problems around of some import that cannot be solved readily and quickly. The majority of people in responsible positions, company presidents, generals and admirals in high military positions, are convinced that the problems that face us in economic and military life are that level of complexity and significance that they warrant sustained research. They require a great deal of thought and a great deal of effort by individuals of high intellectual level. Since these problems are so difficult, it is recognized that we must start now if we wish to obtain results five and even ten years from now.

In view of the foregoing remarks, it is natural to ask why these problems are so difficult. An easy answer is that they are complicated. We face processes involving a large number of interactions, an enormous number of factors, and a bewildering variety of decisions.

The enterprising company president facing this situation decides to buy a giant computer. He has read of what these electronic brains can do, how they are able to perform fantastic calculations calling upon storage facilities for hundreds and thousands of bits of information. What can be simpler and more progressive than to purchase this tame monster and solve problems in this fashion?

The company president buys one of the biggest and fastest machines, turns to his planners and programmers, presents them with charts crammed full with data, and says: "Solve the following problems for me; put 'em on the machine!"

At this, the programmer and the planner are apt to become a bit indignant. "After all," they say, "we know that these machines are fantastic devices. But they are not thinking machines——someone has to tell them what to do."

Now, of course, this may not jibe with what you may have read in the Sunday supplements and in some of the over-enthusiastic publicity that occasionally appears. One somehow gets the impression from these sources that computing machines solve their own problems.

The general impression that one gets is that of a room, tastefully decorated, with a big machine at one end flashing lights and a little table at the other end. One enters, places a problem on the table and tiptoes out. The next morning one finds, in the very same place, the solution, typed out and bound in quiet Morocco.

Fortunately for mathematicians, but unfortunately for executives, things don't work that way.

After all this has been explained, the company president generally says, perhaps reluctantly, "OK, let's hire some mathematicians. If we can't solve the problems by ourselves, let the mathematicians solve it."

The mathematician gravely surveys the problem and he says, "This is a very unsatisfactory type of problem as far as the mathematician is concerned, for the following reasons. In the engineering world, we face precise problems. We may wish to construct a space-ship to go to Mars or Venus; we may wish to construct a multi-stage missile. The question is that of constructing a device that will attain a given velocity, carry an assigned payload, and be able to penetrate hundreds of thousands or hundreds of millions of miles into space—a clear-cut problem."

Whatever the engineering, physical or mathematical obstacles, we can clearly state our objective.

When we turn to the military and business end of the world, we find to our great surprise that we frequently cannot say exactly what we want to do. Since this is a rather startling statement, let us examine it a bit in order to help you believe it. Consider the following sample example. We approach a business man and we ask: "What are you trying to do? What is your objective in running your firm?" Generally, he will answer, "I am trying to make money." At which point we reply, "Are you interested in maximizing the amount of money that you will make this year?" And he will answer: "Well, certainly, I want to maximize the profit over the coming year."

At this, we point out that this isn't all he wants to do. Otherwise, he would sell the business, lock, stock and barrel, and over a period of one year show an enormous profit. Naturally, this idea is rejected—he does want to stay in business. In other words, not only must he worry about the immediate revenue over the coming year, but he must take into account the continuation.

If we press further and ask how he knows whether or not he is in a favorable position, and how he evaluates his business, he will talk about share of the market, new products, efficiency, unit cost, and easily a half-dozen other factors.

After listening patiently, we may say: "Here are the six or a dozen factors that you mentioned. Please write down a precise formula which tells me how you evaluate these factors. Which are most important, and how do you weigh one against the other?"

As soon as we ask a specific question of this type, there is silence. Since we have great faith in experts, the temptation is to turn to an expert and ask him for the answer to these questions. We find to our dismay that there are no precise answers.

Consequently, the very first difficulty that we encounter in trying to tackle some of the formidable problems of the economic and military world, and in trying to tackle them by means of scientific techniques, is that we cannot even state the problems clearly.

After a certain amount of sadness, and self-pity, we decide to introduce artificial but reasonable criteria. Suppose for the moment that we measure success in terms of the amount of money made over ten years, suitably discounted.

Having successfully dodged the difficulty of evaluation, the next type of question that arises in our attempt to apply mathematical methods is: "What happens when a decision is made?"

Suppose, for example, that we decide that a conservative, old-line firm needs some pepping-up in the form of an advertising campaign. Should one spend a quarter of a million dollars, half a million dollars or a million dollars, and how do these expenditures on TV, Radio or Magazine advertising affect sales?

Once again we think of turning to experts, advertising experts in this case. We know, of course, that actually there isn't anyone who can furnish this information.

Consequently, at this point the mathematician again complains. How can one use mathematical techniques if there are no formulas? The temptation is to classify these problems as impossible. We don't know the precise result of a decision, and we don't even know precisely why we want to make these decisions.

For some mathematicians there is a very easy way out of this irritating situation. They turn to other fields.

Unfortunately, the intelligent person who is concerned with these matters cannot avail himself of this simple refuge. He knows from past experience that if the person of ability sidesteps his responsibilities, if he retreats from these problems as too difficult, there is always someone else around with complete faith in his own ability to resolve these questions.

The problem the mathematician must face is the following: Using all his mathematical ability, using all the techniques of modern computers, can he do something in this field which is better than what can be done by an executive with only business experience to guide him? In general, the answer would be—no! If we have a choice of two experts, one a mathematician with digital computers, the other an executive with thirty years of experience, we would certainly rely upon the business man to make an important decision.

In view of the fact that we cannot hope for an analytic solution, is there some way we can bypass the cost in time required for experience? Is there some method for speeding up the process of acquiring experience? With this thought in mind, let us turn to the idea of a simulation process.

A simulation process is a quite obvious engineering idea. It is the concept of the pilot plant, the towing tank and the wind tunnel—a simple and yet fundamental idea.

We say: If we cannot analyze a process in purely mathematical fashion, scientifically according to simple principles and formulas thereby deduced, at very least what we can do is watch it. We will watch the process, observe what happens, and in that way learn what to do.

However, as I have just pointed out, in the business world it appears that one has to watch for quite a long while—ten years, twenty years, thirty years. In other words, in treating really important processes we must realize that the only totally realistic model of the process is the process itself.

It follows that in studying many of the significant problems of the business and military world we cannot use this simple engineering technique in any naive fashion. It is not sufficient to say that we shall merely watch and wait.

We are forced back to use of mathematical and scientific techniques—unconventional, and perhaps more sophisticated in some ways, but still scientific techniques. The use of simulation techniques represents the application of standard scientific methods to areas which have not previously been treated to any extent by scientific techniques. These areas are particularly those in the economic and military spheres.

To take a particular example, consider the problem of running a multi-million dollar organization. We attempt to abstract certain basic features and use these to construct a small-scale model. It is hoped then that something can be learnt from these models.

Now model-making is an art, and quite a complicated one. It is complicated even in the physical world where we have had several hundred years of experience. Hence, it is even more complicated in fields in which only recently have scientific techniques been introduced. Our aim is to study at any particular time a small number of the factors that influence decision-making and to try and determine the effects of various types of policies.

Running these processes, which we call simulation processes, over and over under varying conditions, we hope to build up synthetic experience.

All of this is quite vague, and quite difficult. In attempting to construct a simulation process, we are faced by the question of pinpointing factors of importance. Also we must describe the effects of the various possible decisions.

We thus seem to be right back facing the problems that discouraged us initially. How do we single out important factors and how do we evaluate policies.

What saves us from despair is the knowledge that there do exist people who perform these complicated decision-making roles in outstanding fashion. There are successful executives and there are successful generals. Consequently, there must be ways of overcoming these difficulties to some extent.

In order to see how this may be done, let us examine the idea of the scientific method. One method that has been enormously successful is what we may call the syllogistic approach, the usual logical algorithm.

Starting with a fact "A," we observe that "A" implies "B," "B" implies "C," and "C" implies "D." Consequently, when "A" occurs, we make a decision based upon "D." This has been such a successful method in many fields, that we tend to think that it is the only method that can be used.

Actually, it is not the way that most of us come to conclusions. If you consider any of the significant processes of life, you soon realize that there is never enough known to make successful deductions of the type described above.

What we do when forced to make a decision is to search our memories and try to recall a similar situation. If we can do this and remember certain decisions which were successful, and others which were unsuccessful, we possess valuable clues as to further successful behavior. What we are calling upon is experience, memory of past similar situations.

The idea we wish to stress is that in most situations we perceive more by analogy than by deduction.

Processes that seem to reveal this quite well are those of chess and poker. We all know that there are good chess players and good poker players. To hear some, however, it would appear that there are merely lucky and unlucky players. It is next to impossible to get a consistent loser to admit that his play is defective. On the other hand, these players are beloved by their friends and there is always room for them around the table.

Let us turn to the game of chess. Attempting to analyze chess scientifically, we see that we require a means of evaluating a given position. We need an expert who can look at a particular position and evaluate it as a winning or losing position. What is desired is a formula which will take account of the positions of all the pieces and come out with a yes or no answer—a win or a loss.

Fortunately for the game of chess, nobody has yet been able to do this. Examine the most profound studies of the greatest chess players and you find that they cannot tell why it is that they play excellent chess. They can furnish all kinds of sound strategic principles, and these are of great help. But they have no means of formalizing exactly what they do.

Nonetheless, people do learn how to play chess, some better, some worse. What I wish to emphasize is that our inability to describe a process in precise mathematical terms does not at all mean that people cannot operate efficiently in a situation of this type. In other words, we must not be spoiled by the standard approach of engineering, physics and applied mathematics in general, which demands a completely formulated problem and a clear cut solution. These are luxuries, but not necessities.

If we insist upon asking for the best way to proceed, we may get into difficulties. This is mainly due to the fact that we don't know what we mean by "best." If, however, we agree to try to construct various training processes which will teach people how to proceed in reasonably good fashion in situations of the type described above, then it is quite plausible that something can be done.

The game of poker is an excellent example of this general premise. Here is a game which lends itself to mathematical analysis to a slightly better degree than the highly complex decision processes we have been discussing. Nonetheless, there is no theory which predicts exactly how to play optimally in a five or seven-handed game. However, using native intelligence and experience, one can become a competent, if not gifted, player.

Aware of the difficulties that I mentioned above, and aware also of some of the compensating factors, about two years ago five hardy souls got together to consider the problem of constructing a simulation process that might be useful in training executives. The purpose of this simulation would be to furnish the synthetic experience that would cut down on the usual time required for training.

These five were Don Malcolm and an assistant, Charles Clark, from Booz-Allen and Hamilton, Franc Ricciardi and an assistant, Cliff Craft, from the American Management Association, and myself, from the RAND Corporation.

We were rather an ideal group in that we had few overlapping abilities; what one of us knew, the others did not. Consequently, it was seldom necessary to take a vote, or to discuss matters at too great length. As is well known, the ideal size of a committee is 1.2, and we were violating this to some extent. However, we compensated for this by our ignorance in so many areas. As many have pointed out, it is very important not to let an over-accumulation of knowledge impede progress.

Since construction of games of this general nature had been tried before, we did have the benefit of the mistakes of others. Taking advantage of this experience, we felt that we could construct a workable game if we kept everything fairly simple. We didn't have to be very bright; all we had to do was to avoid the mistakes of predecessors. This was part of it; it turned out that the problem was more complex than imagined. In order to conquer all the difficulties, to some extent, we also had to be lucky. I will explain in a moment why it was that we needed luck.

I would like to emphasize that in complex research programs of this type, mistakes cannot be avoided. Upon first traveling down a road, all bypaths look equally inviting. Only upon having traversed it a few times do we begin to recognize certain of these as dead-ends and others as through-ways.

At the very beginning, we thought that it might be feasible to copy the type of war game that the military forces have utilized for some time. These involve vast quantities of men and equipment. A little thought showed that this was certainly unworkable in a business game.

One of the reasons that the armed forces can engage in vast scale maneuvers is because to a great extent, each of the participant groups follows preassigned patterns.

In the construction of our game, we had to take into account a number of serious constraints on time, expense and complication. Since we were thinking of processes of some degree of realism and magnitude, it was clear from the beginning that we would have to think in terms of digital computers. It is rather surprising that the capacity of a computer is one of the limiting factors in the construction of a simulation process.

There is no question about the fact that computers are really magic devices. In the space of a few hours, with their aid we can solve problems that would have required months even ten years ago. Nonetheless, their capacity is not as great as might be imagined from a quick reading of their publicity handouts. It is fairly easy in just a few minutes of enthusiasm, thinking of all the factors that one would like to include in a model of a business enterprise, to overwhelm completely any modern computer.

In view of this, and in view of the fact that processes that overwhelmed a computer might very well do likewise to the players, we decided to construct a fairly simple-minded game. Only one product would be manufactured and sold, to the tune of a few simple decisions, namely: How much should we produce? Should we build more plant capacity to increase production? Should we spend money on research and development, and on advertising? What price should we charge? These were the basic questions.

The first problem that faced us was: If this was to be a game, how could we tell the players whether they were winning or losing? In bridge, football, chess, or tiddlywinks, we have simple criteria for winning or losing. But in the economic and military spheres, no such simple criteria exist, except perhaps at the very end of the process.

After the equivalent of five or seven years of play, there will be some indication of a trend. It would, however, be nice to know before that time. As I pointed out before, this is a fundamental problem and there is no simple way around it.

Fortunately, we can sidestep it in a very simple fashion—we refuse to tell the players whether they are winning or losing.

Instead, we say: "You're a business man, you evaluate the situation. Use the experience you have had in the business world, and act exactly as you would in a realistic situation."

This, of course, puts the burden of the problem upon the players and upon the construction of the game. The simulation has to be accurate enough so that people will take it seriously, and the players must be mature enough so that they will not try outlandish strategies. They must be people who are interested in testing serious policies.

We have had considerable success in both respects. We have found that the game has been realistic enough to attract attention and interest, and we have been fortunate in obtaining a considerable number of serious players.

One of the most gratifying features, from the professional point of view, has been that the business men consistently beat the mathematicians. This is, of course, the way it should be. If the game is to pretend to realism, it must be true that the person who has had experience in the business world should be able to use this experience to do far better than someone like myself who is merely familiar with all the formulas that go into the game.

I say this with a certain amount of bitterness, because I would have liked to have won. Although I have always had excellent theories, somehow the other players have never been as cooperative as they could be. The result has been that I have never done well, and thus have been forced to console myself with the thought that this is an excellent indication of the realism of the process.

Having passed the criterion hurdle, with a certain amount of agonizing soul-searching, we came to the problem of determining cause and effect. As I have remarked above, we don't know what happens when advertising is increased, or prices are lowered. On the other hand, we must give a digital computer specific instructions. We cannot ask it to use its discretion.

It is necessary to have specific formulas which tell how our share of the market has changed as a consequence of our decisions, and the decisions of our competitors.

We decided that the simplest thing to do, from our standpoint of research and training, would be to choose some reasonable functions with the correct qualitative behavior. If the price was increased, sales decreased and vice versa. But we didn't tell the players what these formulas were. Again our defense was that in any realistic situation these formulas are not known——and may not even exist. Our excuse for ignorance in all these cases is the same: "After all, this is the way things are on the outside."

There still remained a number of other problems. We wanted the game to be flexible, which is to say we wanted definite reactions to changes in policy. On the other hand, we did not wish too strong a reaction, which is to say, we wanted stability.

It is not desirable to have a change of price of say 25¢ on a $5.00 item result in cornering the market and reducing the other players to bankruptcy.

In addition, there was a quite compelling reason for making sure that no crises occurred. The American Management Association is using this business game as part of an intensive course in decision-making. Clearly, if the players are charged approximately one thousand dollars for a two weeks course, it is not desirable to have anyone go bankrupt in two days. At first, we actually thought that it was impossible for this to happen if any reasonable policy was pursued. However, we made the mistake of putting two comptrollers together. Now without any personal prejudice against comptrollers, apart from their peculiar fancy of wanting everything in triplicate, I think that it is fair to say that the philosophy of these gentlemen may be expressed as follows: "Whenever you think of spending a dollar, don't."

The result is that this team resolutely refused to spend any money on advertising, any money on research and development, any money on anything at all. The result was that after two or three rounds, they went bankrupt. Since this was a demonstration game, with the machine programmed for a full five teams, we had to slip them money surreptitiously to keep them in the game.

Forewarned by this, we put in some further magic formulas which absolutely prevent bankruptcy. A team pursuing a foolish policy will not do well, but it will exist.

As I pointed out above, we wanted a flexible game, which is to say we wished to observe an appreciable change when there was a change in policy. Yet we did not want it to be too flexible, to have any violent ups and downs. Consequently, we were faced with a very delicate problem of balancing the interactions. In order to do this, we indulged in a considerable amount of experimentation, playing various stages of the game ourselves.

Members of the group were appointed devil's advocates. One would be chosen to follow a high price, no advertising policy, another a low price, extensive advertising policy, and so on. Occasionally, the person nominated would protest bitterly that his assigned policy did not coincide with his own ideas. No matter, it was necessary to try all extreme policies. As a matter of fact, when first setting up the game, we found that quite a few safeguards had been omitted. The result was occasionally a policy of raising the price from five dollars to ten dollars would corner all the money in the game. This is one of the most serious problems encountered in constructing mathematical models. In any realistic situation, there are built-in properties which automatically eliminate absurd policies. Sometimes, in making a model of an economic situation, we attempt to eliminate what appear to be small effects, and find that precisely these small effects play a determining role in certain processes.

We find then that obviously foolish policies, foolish from the standpoint of actual practice, do very well in artificial games. We call these policies "gimmick policies." In constructing a simulation process, we want to make sure that no artificial policies, known only to the constructors of the game, will dominate sensible policies.

There are a number of games around the country in which this is true. It is hard to see what can be gained from the play of such games. As I mentioned above, rather ruefully, in our game, this is certainly not the case. Even a complete knowledge of the underlying functions does not appear to yield any appreciable advantage.

This is where luck entered. We were remarkably fortunate in the relatively short time that we devoted to the construction of the game to come up with choices of functions and parameters which yielded a reasonably sensitive and reasonably stable game.

Having reached this stage, we decided to try it out first on vice-presidential level executives, and then, in May of 1957, on a selected group of presidents of large companies. The enthusiasm generated by this demonstration was so great that the American Management Association decided to invest a greal deal of money and effort upon a management decision course built around the game. This was started at the end of last year, and appears to have met with success.

I would like to discuss briefly in conclusion what I feel the real purpose of the game is, and how it can be used most profitably. At the present time, no responsible individual claims that games of this type can be used to resolve actual industrial problems. We constantly warn the players that the situations in the game are make-believe situations, and thus not to be taken too seriously. If research and development pays off well, it is not to be concluded that the answer to any realistic problem is more research and development. After all, since those of us who designed the game were partially or wholly in the Operations Research racket, it is clear why we would want to emphasize this feature. We were using subliminal perception some time before, without the aid of a movie screen.

Amusingly enough, one of the engineering magazines rather unethically told its readers how to beat the game. Actually, the policy the magazine advocated was quite wrong, since it was based upon an observation of only about one-fourth of the whole process.

We make no pretense that this simulation process is an operational tool at the present time. Rather, we stress that it is a research tool. Research was for a while quite a dirty word, but it has become more popular in recent times with the aid of Sputnik. One can now assert in public without wincing or apologizing that one is engaging in research.

Apart from the type of training we have mentioned above, how can this research tool be used in a most profitable way? In the first place, I think that it should be used in the universities to a tremendous extent. One of the aspects of human nature, which the universities have refused to cater to, is the gambling instinct. This is not surprising, considering that what used to be called progressive education refused even to admit to the existence of the competitive instinct. Yet, whether we like it or not, it is clear from a study of all civilizations on the surface of the earth, going back to the ancient Egyptian and Sumerian tombs, that humans love to gamble. In these tombs of five and six thousand years ago, one finds dice and board games of all types, ancient predecessors of chess and checkers.

It would seem to me that games of this type introduced into courses in business administration, mathematical economics, operations research, and many other subjects, would stimulate the students to a considerable degree. At the present time, a number of games modeled after the AMA game are being used in various universities around the country.

Secondly, I think that games of this type can be used as super intelligence tests. At the present time, intelligence tests, although given widely, are not taken too seriously. One of the reasons for this, it is generally agreed, is that what we call an intelligence test is actually a measure of only a few of the facets of human intelligence.

One of the basic aspects of human intelligence, and animal intelligence as well, is the ability to adapt to environment, and particularly to changing environment. In other words, intelligence should be tested in terms not of what one knows, but of what one can learn.

It is clear that no static test can measure this feature of intelligence. We need a dynamic process, precisely of the general nature of the simulation process described above. Although there is little doubt that processes of the foregoing type can be used for these purposes, much remains to be done before they can be used for quantitative purposes. It is not as easy as one might think to determine what it is that is being measured and to what extent.

I do believe that these simulation techniques will assume a greater and greater role in the future, and eventually become operational tools. The appropriate story on which to close is the following.

A stranger who loved to gamble came into a little town and inquired about the possibility of some action. He was directed to the back room of a local saloon where there was a roulette wheel. A kindhearted townsman pointed out, however, that the wheel was crooked. The stranger shrugged his shoulders and said, "I know, but it's the only wheel in town."

References

The reader who is interested in learning more about these matters may consult the following work where additional bibliography is given.

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