TRANSACTIONS OF SOCIETY OF ACTUARIES
1969 VOL. 21 PT. 2 NO. 59 AB

COMPUTER MODELS AND SIMULATION

Computer Modeling as a Management Tool

I. What are some life insurance company applications of computer modeling that have proved useful for agency problems? Investment problems? Administrative problems? Pricing problems? Other?
II. Why was computer modeling used rather than another method (such as analytical solutions)?
III. What applications have proved not to be useful? Why not?
IV. What methods proved to be more successful than computer modeling?
V. What dollar and personnel commitment is needed to make effective use of computer modeling in a life insurance company?

New York Regional Meeting

MR. RUSSELL M. COLLINS, JR.: The first use of computer modeling that I would like to mention applies when it is either impossible or extremely costly to observe a real process in order to obtain the desired information. The classic example of this perhaps is the way wind tunnels are used in the aircraft industry. Conceivably, the aircraft industry could build an airplane, put it out on the runway, and see whether it works. Essentially, what the aircraft industry has done is to build a simulator, so that they can build a model of this aircraft and experiment with it in a simulated environment to discover some of its characteristics rather than having to go to the expense and cost in both money and human life of doing it the hard way. Many times businesses, and maybe insurance companies, try to fly without a wind tunnel. In other words, a lot of effort is expended on something that turns out to be a flop.

Another situation in which computer modeling can be used is where a system is too complex to describe in mathematical terms, or mathematical formulations are too complex to solve analytically. Actuaries have, of course, been simulating for years. The model office is a good example of a relatively simple simulation device. But, when you get into a model of an economic system, or model of a firm, these models can be made extremely complex and more accurate (with the aid of a computer) than the simpler model office with which we are accustomed to working. In fact, computer modeling and simulation may well be used to study and experiment with the effects of internal or external changes on a system, such as internal interactions between various parts of the system, or how a particular management decision affects the future course of a corporation, or how changes in the economic environment of the company will affect the company.

It seems obvious that our decisions are going to have varying impacts and varying effects on our business, depending on the external economic environment. It is a wonderful idea, if we can figure out how to do it, to tie a corporate model into some kind of insurance industry model, which in turn is tied into a model of the economy.

Computer models can also be used as educational devices. A good example of this is gaming, on which Mr. Halmstad will comment extensively.

The experience of designing a model may be more valuable than the actual modeling itself. In other words, simulation is a learning experience as well as modeling. In building a model of a firm, for example, you need to talk to the managers of the firm. These managers and you will have to think more precisely about the business they are in and about the effect of the decisions that are made. You may feel that you have not done a very good job of quantifying your problem, but you nevertheless will understand it a lot better when you are through. Modeling can be used, for example, to experiment with new situations, about which there are few data, such as, perhaps, entering a new product line.

Another area where modeling is used and where actuaries have done much work is in the situation in which you are looking at a probability distribution function and you need to know the whole distribution. Information about the moments is not enough. A good example of that is the stop/loss problem, where you need to know a lot about the tail of the distribution. It is not enough simply to know what the moments for the distribution are. Our experience with this, incidentally, provides a good example of where another method appears to be more effective than modeling.

In one of the first problems that we attacked, we tried to use modeling to determine the claim distribution of a closed group of lives. We used the Monte Carlo approach, in which we essentially exposed each life to death by selecting random numbers from the unit interval and developed a claim experience for the group. With the computer that we had at that time, this turned out to be a very lengthy process. So we turned to another method and used the convolution method, subdividing the group into homogeneous subgroups. We found that we obtained faster and more complete results, and we were able to verify that they were good results because the runs already made on the Monte Carlo basis were available.

The effective use of computer-modeling techniques requires extensive data, particularly as the models are refined and we look at more factors.

It appears that we are moving toward broader data bases, where there will be a wealth of data available in one data base or bases. Certainly the analysis of past activity is a requirement for a management information system. In other words, a transaction history is needed. Finally, we need the availability of data and capability to manipulate it for research purposes. It appears that, as management information systems are developed, we will see a more and more effective use of computer-modeling techniques. We have just seen the beginning.

Finally, a comment on the question of the investment in modeling. A lot of us wrote these initial computer programs and did our initial work at home on the kitchen table, so to speak. It is pretty difficult to estimate what kind of an investment that represents. But, as we get into more ambitious and more complex modeling projects, there is no doubt that significant investments are involved. For models of the size that John Hogan reported recently to the Society, an investment of well into six figures would appear to be necessary.

One point that I consider most significant is that such costs must be considered as part of the investment in the company's planning process.

MR. DAVID G. HALMSTAD: Insurance management games have been available for some time now. In a 1960 paper in *Operations Research,* Mr. John McGuinness described a casualty insurance management game. Although Messrs. Collins and Hill were working on a life insurance answer even then, they did not publish their efforts until last year (*TICA*, 1968, Munich). Inasmuch as Collins and Hill have described their game, I will outline a new gaming model that we are working on and develop some arguments for using this type of computer model.

Although gaming models can be developed without the use of a computer—and many of these are very successful—most of the larger games must use the computer to handle the many calculations needed. Gaming, in this context, directly involves both the computer and people. This is reflected in the principal use of gaming models as training mechanisms. People make decisions, and the computer simulates the environment in such a way that results are dependent on these decisions. By a repetition of this process, the "players" learn to use the results from previous decisions to make better ones in the future. Games are usually competitive, insofar as several teams of players are involved. Competition may or may not be included in the computer program. If it is, it is usually reflected in the allocation of resources or customers among the teams playing.

Gaming is best suited for decision contexts in which a fluid atmosphere requires individual decision making to take place. While this occurs at all levels of insurance company activity, there are perhaps two areas where it is most clear—among the company's executives and on the part of the agent in the field. Games for management have been developed, and they are used in several levels of training. An extension of the Collins-Hill game has been used in New York City for summer actuarial trainees, permanent actuarial students, recent Fellows, and an ACLU company management class. It has been well received.

Our new game is for agents and simulates the selling process. Our training objective for this "sales" game is very simple—we hope to make it apparent to a prospective agent that his function involves a great amount of personal decision making. We want particularly to impress on him that a rational allocation of his sales effort and his time is an important ingredient to his success. Imagine, if you will, the following scenario for our game.

The trainee is seated at the console of a computer, either a small research computer or a terminal of a time-sharing operation. Above the console is a large map of a hypothetical city. The map shows the central business district in which most of the city's offices are located, the industrial areas where large manufacturing plants can be found, and various residential areas differentiated by average family income. His preparation for the game has included a more detailed description of this sales environment: who the chief life insurance competitors in the area are, what the options that he has are (such as cold canvassing either in person or by phone or personal contacts with his friends and acquaintances), what the average times of travel between and within the areas of the city are, and what sources of information are available in the game. This latter information will include, for example, birth and marriage announcements and listings of his company's current policyholders in the area arranged by the date of their most recent purchase or by selected servicing dates, such as conversion or insurability rider option dates.

The player signs on with the game. He enters several decisions about the types of prospecting he will initially follow. The computer will establish the names and characteristics of the player's personal acquaintances by printing a list preassembled for this purpose. Several possible contacts may already be available in his office; they will be presented with whatever data are known about them. This information will include the nature of the contact—a personal referral, a response from a "door opener" sent out by the agency, or perhaps a clipping from a newspaper on a recent promotion—and may include information regarding the prospect's age, type of job, present insurance, or even the type of insurance in which he is interested.

When the player has received these lists of prospects, he makes up a time sheet of the order of his activities during the next day. In this context "day" refers to the operational time of the game, not to real time. His activity decision includes a tentative time set on each appointment or type of prospecting (such as a cold canvass in a particular area).

The computer then plays "nature." It follows the agent's course throughout the day and prints out the results from these approaches. Information that will be provided in these results will include, but is not limited to, the results of his approaches: "door slammed" or "not interested," request for return at a later date, request for information, or more analysis. It will also develop some additional personal information on the prospect, such as the need for a rated policy, the prospect's general income level, or the size of his family, and the player may get references to other prospects. Sales, of course, will be noted. Occasional unplanned encounters will occur. These may be strictly unplanned and force a readjustment of the day's schedule, or they may occur "on impulse"—for example, when a schedule of approaches has not taken up the time allocated. Times for travel and nonbusiness lunches will also be shown. Some office work will be planned and simulated in the same way.

After the player has received the results for the day, which will include any additional sources of prospects that occur, such as mail inquiries, he will be prepared to set up his next day's schedule. The computer will also play "secretary" and remind him of previous contacts which he has promised to follow up.

After a few "weeks" of this interaction between the computer and the player, the game is completed. An analysis of the player's sales "assets" (such as the number of prospects as yet unsold) will be tabulated along with the commissions already earned by the agent.

The probability of a sale in our current models is dependent on the prospect's age, sex, occupational classification, family status, and a "propensity to purchase." This latter factor is in turn a continuous mathematical model whose variables are amount of current insurance, time since previous insurance purchase, recent changes in family and employment status, number of contacts recently made by agents of all companies, degree of personal risk aversion, attitude toward fixed investments, and the time since the agent-player's last contact. When a policy is determined to have been sold, factors on the existence of competition, previous insurance with the player's company, and like variables will be introduced to determine whether the player gets the sale. The framework for our models follows that of Mr. Bragg's paper "Prices and Profits" (*TSA*, XX, 44).

We expect that this game will grow increasingly complex as it is played. Initial stages of the game—with much simplification of the options allowed—will likely be unrealistic. By getting agency personnel to play these simplified models, we expect to find out much more about what the sales process really is like. It is much easier to get constructive criticism of a mathematical model by using a simplified version of it and directly involving the expert in using it. Fortunately, gaming provides a natural method by which this may be accomplished. This has been our experience with the Collins-Hill management game. Although we have added a great number of modifications and extensions, new areas for refinement are found each time it is played. We expect that the comments we receive from agency managers and field representatives will follow this pattern.

A related project, on which we are just beginning, is to build a detailed financial model of parts of our company's agency operations. The stochastic variables that are important to this model, of course, include the probabilities of sale that are fundamental to the selling game. However, at this level we also need a model for the termination rates of individual agents. And these models, with all the others affecting an agency's success, will need to be related to whatever data are available on the company's actual operations.

One value to be gained from gaming models is in the game-builder's increased ability to organize mathematical models of variables usually considered to be ill-structured. When data are not directly available or when a relationship between variables is not clearly understood, the model-builder can still provide assistance to the decision-maker. With an imaginative array of alternative models and with the participation of an expert in the area, workable hypotheses about the unknown relationships can be evaluated by the reasonableness of the results they produce. This process, like gaming itself, tends to get the expert acquainted with the possibilities of modeling.

Although a game can develop into an intricate model, it is unlikely that any game will be used directly as a base for a projection or experimental "company model." After all, to be effective a game must simulate a possible actual situation and yet keep the number of decisions to be made by each player at a manageable level. A company model, on the other hand, must closely follow the actual workings of the company rather than simply provide an aura of possible realism. This normally involves many more free variables than can be used in a simple management game.

Most life insurance company models begin with the simple computerization of a financial analysis which has been done previously by technical staffs. This may be a detailed study backing up the gain and loss pages of the annual statement, or it may be a less refined technique used for surplus projections. The only problems that should occur in the development of operational models of this type are the availability of programmers to do the work and the administrative problems of keeping various parts of the model consistent with one other. There is an associated problem which must be cleared up before the model is begun; that is, the planners must know exactly what uses they have for it. This is not always as easily solved as we might think.

The question relating to the use of computer modeling rather than analytic solutions is also particularly interesting to me. A few years ago I was asked to examine the amount of fluctuation that might be expected on a new product with high benefits and a low premium. The expected claim probabilities were fortunately very simple. The amounts of coverage were also limited to only a few values. The original request strongly suggested that I simulate possible claim results on this policy. I pointed out that the study would be finished more easily and quickly if I applied risk theory, but risk theory was not an acceptable technique at that time. So I proceeded to carry out the simulations that had been requested. I followed the various methods outlined by Sidney Benjamin in his paper to the 1964 International Congress of Actuaries. For illustration and to get some estimate of computer time, I made only one run on the "direct" basis, which Benjamin regards as a waste of time. It showed that we would not be able to obtain any significant results using reasonable amounts of computer time. Programming for this direct simulation was very simple, but the computer costs were simply too great. Mr. Nathan Jones ran into this same problem in a study he presented to TIMS in 1958.

I then proceeded to follow Benjamin's other methods. It is interesting to note that Benjamin's refinements of the simulation technique lead one directly to an analytical method. He begins with a "one death per random number" method. At the Duke Actuarial Conference on Simulation, he described a variation of this method which reduces the need for storage in the computer. After noting that this method simulates rare events "rarely," Benjamin develops a method for forcing the occurrence of rare events. This method in part relies on an assumption that the number of deaths will follow the Poisson distribution. This is the first place at which part of the analytical solution enters. The simulation aspect of the forced-death method similarly may be eliminated when it is realized that a convolution of the claim amounts can replace the simulated total claims for a given number of deaths.

Therefore, once Benjamin's forced-death method was illustrated, I proceeded to carry out the usual convolution calculations used in the risk-theory model. Fortunately, only a few deaths were expected in a given year of experience. Now, of course, once the convolution method—an analytical technique—has been introduced, one may point out that a quicker way of obtaining the same results is to use the Esscher approximation. This is what I presented to the people who asked for a simulation solution. The structure of the problem, *in this case*, was such that an analytic solution was the one clearly called for.

With regard to the cost of computer modeling, many of the costs of personnel and time that are involved cannot be precisely defined. Much of the background material that is needed for a good simulation or another type of computer modeling is usually done outside the office by the person most directly involved in organizing the study. In my own strange accounting system, I discount rather heavily the costs of my own time for analyzing random number subroutines, checking once again on the properties of the Laplace transform, or digging through applied mathematical journals to see what has been done. For a large project, such as a company model, it is possible that the time used by programmers, actuarial students, and even clerks may be only marginal if the work is done in slack periods. For a department in which specific responsibilities for modeling and other management science techniques are assigned, the allocation of costs is obviously simpler and the amounts are higher. One study indicated that the costs involved in the development of a management game ran as high as $60,000. This was a large project and involved many committee meetings among people that would be affected by it.

MR. OWEN A. REED: My company insures about $7½ billion of group life insurance, with an annual premium of about $55,000,000—both figures net of reinsurance.

By 1963 group life premium rates were down to a level which was quite low compared with that of 1950, especially in Canada, where the major portion of our group life insurance portfolio is concentrated. In addition, group life manual limits had increased substantially, as had policy lapse rates and unit expenses. Further, a number of companies, including my own, had moved to the "accounting" form of experience rating, under which 100 per cent claims credibility is often given for quite small groups—with manual premiums of $10,000 or even $5,000—and negative dividends were becoming more common.

We therefore felt that a complete investigation of the entire premium, underwriting, and experience-rating structure was required; and in September, 1963, a study was begun which took about three and a half years to complete. The time probably could have been cut in half with a larger capacity computer, such as a third-generation computer.

One of the principal applications was a study of group life manual limits and the pooling of large individual amounts of group life insurance. For fully pooled policies a model was constructed consisting of seventeen amount classes whose claims-distribution characteristics were very close to those of the actual portfolio. This model assumed that claims by number of lives would follow the Poisson distribution.

By the use of a small computer it was possible to establish the quantitative effect of increasing the amounts of insurance in the highest-amount classes, of adding additional classes with high amounts of insurance, and of changing the mortality assumptions for any class. In this way we were able to decide what risk (or contingency) charges were required under different circumstances and therefore what manual limits we were prepared to offer for fully pooled policies.

For larger policies, whose claims experience is given some credibility, we used Monte Carlo simulation methods, again assuming that claims would follow the Poisson distribution. Using model age and amount distributions for groups of a number of different sizes, we observed the effect of changing the levels above which large individual amounts of group insurance were pooled on the net stop-loss premiums. This was done at stop-loss levels, such as μ, $\mu + \sigma$, $\mu + 1.50\ \sigma$. Using the results, we decided upon a set of large-amount pooling levels. In order to help decide upon manual limits, however, it is necessary to study the claims distribution of the large-amounts pool itself, since the risk is being transferred from the individual group policies to this pool. A model similar to that used for the fully pooled policies was constructed for this purpose. For a large company which does not wish to reinsure any of the risk, the net stop-loss premiums for the large-amounts pool must be kept acceptably low.

Having settled upon the large-amounts pooling levels, the next important application was to experiment with different credibility formulas, using model claims distributions. If dividends are to be paid once each n years, it is necessary to decide what credibility should be given to each current n years' experience and also what credibility should be given to cumulative experience, upon which expected claims are to be based.

Since it is possible to choose from an infinity of credibility formulas, some of which, however, would require very high risk (or contingency) charges, the idea is to search for those which give both acceptably high credibility and acceptably low risk charges—if such a formula can be found!

The computer model used was more sophisticated than any of those I described earlier and was given the name of "fund simulator" or "group life asset share simulator." Using a given set of premium rates, experience expense factors, and experience policy lapse rates, and a given experience-rating formula, group life asset shares were simulated, say, for ten consecutive policy years, using Monte Carlo techniques. The results can be used to establish the risk (or contingency) charges required in order to obtain ten-year asset shares which are, on the average, positive or zero. After considerable experimentation it was possible to obtain a set of premium rates corresponding to each experience-rating formula, and hence (we hope) both an acceptable experience-rating formula *and* scale of premium rates.

In answer to the question of why computer models were used, none of the problems discussed have simple analytical solutions, and any reasonable study involves many, many calculations. In short, computer assistance was a "must," and for the most complicated situations we opted for Monte Carlo techniques.

What applications have proved not to be useful? Using a computer model of our group life insurance portfolio, we tried to complete a study of the effect on claims experience of aviation catastrophes. I am sure we have the right method, but we still do not have the computer capacity to get the detailed solution being sought.

With regard to dollar and personnel commitment, it is probably best to be slightly understaffed and to impose rigid rules regarding the waste of computer programming and running time. These constraints should lead to considerably more use of the gray matter and less sheer trial and error. Good programmers are scarce, and they also greatly dislike having to make changes in complex programs—especially several months after they were originally written.

Each complex computer application requires a task force. Unless the investigator is also a good programmer, the task force will vary upward in size from two.

For the group life experience-rating problem I would recommend a three-man task force and a goal of eighteen months to two years. The task force would not have to work full time on this problem. This job cost us about \$35,000–\$40,000 in salaries (before overhead) and about \$9,000–\$10,000 in computer time. With current computer capacity the cost of doing the same job today should be quite a bit less.

MR. HALMSTAD: From what I have seen that has been done with modeling in both insurance and other industrial applications, FORTRAN or another general language, such as COBOL or ALGOL, is the most flexible framework to use. Even the specially designed simulation languages—GPSS, SIMSCRIPT, and so forth—have lost popularity to FORTRAN. Occasionally one does need to use a basic language, such as 1130 ASSEMBLER. For example, a random number generator can be more efficiently done in a basic language than in FORTRAN from design, programming, and running-time points of view. Still, I think that FORTRAN is the logical framework for most actuarial personnel.

CHAIRMAN CECIL J. NESBITT: To return to Mr. Reed's discussion, I wonder if he would remark on the fully pooled policies model. This involves computing convolutions in respect to class claims rather than individual claims.

MR. REED: As I described, we ran the actual portfolio and from some experimentation tried to gauge the effect of using intervals rather than exact amounts for individual group life policies. For each amount class we worked out the probability of zero claims, one claim, two claims, and so on, up to the number of claims which we deemed to be adequate. Then we compounded the probabilities of two classes to get the amount of distributions for the two classes combined, pulled in a third class, and got the amount of distribution for three classes combined and so forth. This is exactly what Mr. Collins was describing earlier, I believe.

CHAIRMAN NESBITT: The important point there is that you are convoluting the results in classes and not convoluting the results of individual claims.

MR. REED: That is correct. I think the other way would take a tremendous amount of computer time and a lot of memory space.

MR. CHARLES L. TROWBRIDGE: We at The Bankers Life have developed a rather simple computer simulation of the operation of a mutual fund. This model is deterministic—that is, it has no random variables. It is programmed to produce more than twenty different outputs, each for twenty years. The outputs include such things as value of assets, total sales, number of accounts, number of shares, total commissions paid, dollars available for sales overhead, dollars available for investment management, dividend and capital gain distributions, and values of the mutual fund share.

The results produced are not more reliable than the inputs plugged into the model. These are nineteen in number, and each can be varied for any of the twenty years. These are such things as number of new accounts, average dollar sales to new accounts, average dollar sales to old accounts, rates of investment performances, rates of loading and commission, rates of redemption, rates of reinvestment. Once the inputs and outputs have been defined, the remainder of the model building lies in specifying the relatively simple equations which connect them. Almost anyone in our company who wants to try his hand at setting inputs has access to the model, and results can come back in the same day. We are finding that setting realistic and self-consistent inputs is not the easiest thing to do.

To suggest that simple model building does not need to absorb all your energy, we estimate that our investment in this model to date is less than one man-month, spread among several people, both actuaries and EDP specialists. In the interest of the sharing of knowledge, and in the thought that some of you might suggest worthwhile improvements, we will show the details of this simulation to anyone willing to write for it.

MR. THOMAS P. BOWLES, JR.: May I ask an "iffy" question? If the Metropolitan were a stock company and if the Metropolitan had profit centers and if the Metropolitan measured the cost of each activity on its profit centers in order to determine the profit generated by such an activity, to what extent, in your judgment, would this type of game playing have limitations imposed by your top management?

MR. HALMSTAD: That is a tough one. The use and value of games may be just as limited for an organization that deals only with research as they are for a large corporation. My personal goal, and where I believe we are obtaining a real payoff from "gaming," is in getting the interest and co-operation of the experts in the field I am studying. Still, I doubt that gaming could be justified by profit potential in any organization. If controls were imposed, they would probably take the form of time-costing systems. As a result, I would increase the work I do over the "kitchen table" to include some time that I can now squeeze into office work. The main costs that would then have to be justified to the company for "research and development" would be only the computer time needed.

MR. JOHN H. COOK: It has been stated that computer models have been used as a training device and for executive decision making. These models reflect interaction of many complex factors, and the consequences of these interactions are often questions of subjective opinion. I feel that the results of the models are extremely sensitive to these interactions.

My question is this: How do you propose to train an individual to become a builder of effective models, particularly for the purpose of executive decision making?

MR. COLLINS: It takes someone with some good experience in the simulated area of the business. I understand that, in the construction of some econometric models, as soon as a program was running, an expert was called to come in to observe what the program was producing and to make comments, criticisms, and so forth.

Mr. Halmstad mentioned this process in using the game model to build toward the problem-solving model. A key point is that you need to involve all the people in the planning process in the modeling, and I think that this is where the learning experience of modeling comes in.

MR. HARRY D. GARBER: Are the assumptions and probability distribution underlying the agent's game that you have described based on actual experience?

MR. HALMSTAD: We hope that, in the process of using the sales game, we will find out from people who know more about the sales process whether or not the game is realistic. Perhaps we will be able to gather some data, and, of course, once that happens, we are probably going to have to change the game somewhat.

Let me emphasize, however, that the purposes of our sales game are to illustrate the importance of rational allocation of sales effort and time and to get our sales people involved in computer modeling. To accomplish these objectives, the sales game need not be completely realistic.

MR. GARBER: If you "experiment" with people inside the environment who know some of the "real" life, they will tend to expect "realistic" answers. If the game is ill-formed or has many bad assumptions, I am afraid that you may have trouble getting them to take it seriously, particularly when your audience probably has little awareness of the objectives involved.

Atlanta Regional Meeting

MR. HARRY D. GARBER: As is usually the case with panel members at Society of Actuaries' meetings, I had some trouble with the specific wording of questions I through IV in the program. To get around these problems, I drew up a new set of questions on which to base my discussion of this general subject. My questions are as follows:

1. What are the principal characteristics of computer models, and under what circumstances are such models useful?

2. What are the requirements for a successful computer model?
3. What are the limitations of computer models?
4. What applications illustrate the advantages, requirements, and limitations of computer models?

I believe that, in discussing these questions, I will bring out essentially the same points which the questions in the program were intended to elicit.

A computer model is a program which describes a current (or proposed) work or decision-making process in terms of mathematical relationships, functions, and decision rules. The process described may be entirely a mental or decision-making one (the management of an investment portfolio), or it may combine physical movement and decision making (for example, the processing of applications for new insurance). Since a computer model is designed to represent a real business system, many of the assumed relationships contained in it may be expressed in terms of probability functions. If the computer model involves several such probability functions, the processing of one case through the model is not necessarily significant; really significant results are obtained by running the model for a number of cases and are stated in terms of an average result and the deviations expected from this average result.

A computer model is a necessity in the solution of management problems in which there are a large number of variables, complex interrelationships between the variables, and/or many relationships involving probabilistic functions; because of the number of calculations involved, it is not practical to use any other approach. In my experience, another usual characteristic of a computer model is that it is constructed to permit observations of the effects of (1) experimental variations in the relations between different variables, (2) new decision rules, (3) new procedures, and (4) changes in the outside environment. Where the model is of a physical process, such as the new issue process, the use of computer models permits experimentation with new ideas for improvements in the process before they are introduced into the actual process. This is important in avoiding untried changes which could damage relations with policyholders, agents, employers, and the like. If the computer model is a model of a decision-making process (for example, portfolio management), the experimentation may take the form of trying out different sets of decision rules in different economic periods to determine which set produces optimum results.

I think that there are four basic requirements for a successful computer model. If all four of these requirements are not met, the model will not be a successful one. (I assume that, in terms of the questions included in the program, an unsuccessful model and "an application that has not proved useful" are synonomous.) These four requirements also apply, I believe, to any scientific approach to management problem solving.

The *first* requirement for a successful model is that the objective(s) of the model must be defined before the model is constructed. For example, in the investment of funds we might model (1) the decision-making process, (2) the administrative procedures, or (3) some combination of (1) and (2). Before constructing the model, however, it is essential that the objective be established.

Another example might help to point out the importance of this requirement. In developing a model of the individual policy underwriting process, we might set as an objective that each substandard class will produce mortality results (relative to standard mortality) consistent with the assumptions in the substandard premium scales. Under this approach, the underwriting model would be designed to obtain all the medical information necessary to assure (within a specified probability level) that the classification is correct—regardless of cost or applicant inconvenience.

On the other hand, we know that every time an additional underwriting requirement is requested, the issuance of the policy is delayed, and this may decrease the probability that the applicant will accept the policy even if the information, when received, does not adversely affect the rating. Because of this possibility, the objective of the underwriting process suggested above (i.e., correct classification) may be too limited, particularly when the value of the information requested in terms of increased premium income will probably not be greater than the sum of (1) the cost of the policyholder's and agent's dissatisfaction at the delay in issue and (2) the cost of obtaining the information itself. Therefore, a better (and more complex) objective of an underwriting model might be to maximize the gain to the company from the underwriting process, recognizing that this process affects the amounts of premiums collected (and from whom such premiums are collected), the amount of benefits paid, and the underwriting expenses.

In studies of other management problems, you may find that the evaluation of objectives requires that dollar values be attached to such intangibles as customer satisfaction and so forth.

The *second* requirement is that the process should be describable by a model. There is no point in attempting to construct a computer model in an area where there is no basic knowledge of the relationships involved. For example, I do not believe that there is any known way of measuring (in quantitative terms) an individual's reaction to a particular advertisement. It would be fruitless, therefore, at this stage in our knowledge to attempt to develop a computer model whose results depended on such a measurement.

The *third* requirement is that the functional relationships required by the model should be readily available from existing data or should be derivable from studies of current processes. This is a very important requirement. If there are large and important areas in which the analyst has to assume basic relationships, the model may provide extremely valuable insights (if the analyst is brilliant, or lucky); on the other hand, it may be valueless.

Even though the required data are available, they may be applicable only to the time period in which they were gathered. We once constructed an agency force model for purposes of determining the number of agents we could expect to have on hand any time in the future, and the amount of their production, given certain recruiting plans. The heart of the model was a set of probabilities, forecasting the agent's status (in force or terminated) and production class in contract year (n) for a given status and production class in year ($n-1$). While this set of probabilities gave good results for the particular economic period from which they were derived, we found that, when we tried to project future results based on these probabilities, the projections were quite far from the actual results.

(The class of decision-making models represents a partial exception to this requirement. Many of these models were designed with the objective of establishing via simulation certain of these fundamental relationships, and, obviously, these relationships can be determined only through the use of the model.)

The *fourth* requirement is that the process being investigated leave plenty of room for improvement. No computer model will be a perfect representation of the process being modeled, and, if the improvement which a particular course of action appears to offer is only a slight one, it may not be a real improvement but only an apparent one resulting from erroneous assumptions in the model. Also, developing a computer model is expensive, and the benefits should be commensurate with the cost. On the other hand, a small percentage of improvement in your investment operations or the efficiency of your agency force can yield enormous returns to the company.

In my view, there are two basic limitations to computer models:

1. In the case of the large class of computer models used for simulations, the primary limitation is that they do not automatically provide an answer or even a range of answers. We can determine a single result for a given set of variables and functional relationships and for selected values in the case of probabilistic

relationships. If the result is, for example, the net return from an investment portfolio, how do we determine the decision rules which will optimize our return? For any multidimentional problem (of the type which would cause one to use a computer model in the first place) there is no recognized solution process; a trial and error approach must be used, an approach which is expensive of computer and analyst time and, worst of all, is uncertain.

2. Another limitation on the use of computer models is the cost which may be involved in establishing the basic data and relationships underlying the model. The development of valid probabilistic data may be particularly difficult and costly.

On the other hand, there is tremendous value in going through the development of a model. More may be learned in developing the model of a given process than will ever be learned in the exercising of it. In this sense, no model need be a failure.

In my discussion so far, I have touched on a number of possible applications of computer models with some success in the areas of portfolio management and individual policy underwriting and without successful results in the case of an agency force model. The following paragraphs are a few additional comments on other areas in which computer models may prove useful.

1. One of the best applications for computer modeling is in the design of EDP systems. For example, we developed a computer simulation model to assist us in the design of a real-time EDP administrative system for individual insurance policies which involve the maintenance of a single set of master records in the home office and the inquiry and updating of these records for all types of transactions from our eighty field offices. As you know, in an EDP system, the processing of individual cases is generally much faster than the input/output operations, particularly when random-access equipment is being used. In order to get the through-put required, it is necessary for the machine to have several cases residing in core memory at the same time, one case being worked on and the others awaiting input from the files. Because of core memory size limitations, it was necessary for us to store both policy records and programs on random-access files and to get them from the files when needed. The design problem we had involved two questions: (*a*) What programs should be permanently retained in core memory? (*b*) What maximum program size should be used?

Essentially, both these questions involved finding the optimum balance between (1) a solution which involves very little available core capacity for holding cases awaiting input, because it was used for permanent program storage or was occupied by very large programs required to process the few cases in the system, and (2) a solution which, because of a very small maximum program size, permitted many cases to reside in the system simultaneously but, in turn, required many input operations per case in order to obtain all of the sequential programs needed to process the case fully.

2. Almost any administrative operation which involves the movement of papers among several stations and which is time-sensitive is an ideal application for a computer model. The processing of new business applications for individual insurance policies is a perfect example of such a process. A computer model can be very useful in studying the general flow of applications in a new business area. In addition, if the company has sales campaigns which cause the number of applications to vary significantly from month to month, this type of model can also be very useful in studying the question of optimum staffing (i.e., the staffing which can handle peak periods without too much agent and customer dissatisfaction and which does not constitute too large an excess during slack periods).

3. The area of individual policy marketing is an area in which computer models will be used to significant advantage some day. Unfortunately, very little of what takes place in a sales encounter is known, and this represents, in my opinion, a severe limitation of what can be done in this area. Very little is known about how many sales encounters there are, what the ratio of sales to sales encounters is, how this ratio varies according to the age of the client, the client's present insurance coverage, the client's relationship to the agent, and so forth.

4. In the area of security investments, there is a good deal of data on companies and securities, and this represents a fruitful area for computer modeling at the present time. On the other hand, very few data are available in the area of mortgages and real estate investment, and this fact must limit what can now be done in the use of computer models in these areas.

With respect to question V, it is my judgment that a substantial commitment is needed to make effective use of computer-modeling techniques in a life insurance company (or in any other business institution).

This commitment involves (1) a minimum of two or three persons with academic and/or work experience in the application of quantitative methods to business problems, (2) support personnel (programmers, clerks, secretaries), and (3) easy availability of computer resources. In addition, the development of computer models must be an interactive process between the quantitative methods specialist and persons (often at high levels) who know the insurance business and who have the problems to be solved.

On the average I would estimate that each quantitative methods specialist employed will involve a cost of about $50,000 per year for salary, overhead and fringe benefits, computer time, support personnel, and the time of persons using his services. A minimum installation of two or three quantitative methods specialists would involve an annual cost of approximately $100,000–$150,000 per year. Moreover, even after the proper staff has been assembled, do not expect an immediate payoff. I believe the key to a successful management services group is the establishment of solid relationships between the quantitative methods specialists and the users of their services, based on mutual respect and understanding. The establishment of such relationships is a delicate and time-consuming process.

MR. WILLIAM F. SUTTON III: Do you attempt to justify the cost by the results you get from your methodology simulation?

MR. GARBER: Methodology is something like scientific research; you do not know where you are going when you start out. Therefore, it is important to avoid elaborate justification in advance. However, you should deal with areas that have possibilities, such as investments or marketing.

MR. JAMES LEE LEWIS, JR.: You mentioned that securities analysis would be one place that might be quite fruitful. Do you mean to include portfolio analysis? Do you feel that portfolio analysis at its current level is really appropriate for life insurance companies?

MR. GARBER: We are working on security analysis now. If we continue to show results, as we have so far, our people may be willing to turn over to computers the management of the basic blue chip stock portfolio.

DR. ELI ZUBAY:* One of the points which should be made today is that computer models are one of the tools of management and that the manager does not automatically make his decision on the basis of the computer results. He appreciates the fact that models are based on certain assumptions which may or may not be satisfied in a given problem situation. There will always be room for intuition, judgment, and the assumption of risk by a manager in any decision situation. The value of computer models stems from the opportunity to consider more variables, to examine a wider range of choices, and thus to effectively narrow the range of uncertainty for these problem situations where judgment must be exercised.

* Dr. Zubay is Professor of Actuarial Science at Georgia State College.

In the time allotted let me review briefly a few of the articles that have been written in this area. Some of them have already been mentioned. I believe that these papers should be viewed from the point of view of the type of problem considered and the model developed rather than from an analytical treatment of the assumptions made. Each of the authors, I believe, would agree that some of their assumptions were simplified or modified so that they could develop a model with which they could cope.

Let us consider first some applications pertaining to agency models and marketing. I would like to call your attention to an article by Dwight Bartlett entitled "The Simulation of Model Agencies Using Monte Carlo." In his paper he made various assumptions with regard to his company—that is, the probability of an agent's producing a certain amount of business in a given calendar year as a function only of the amount of business that the agent produced in the prior year. He also gives a very lucid explanation and illustration of the Monte Carlo method of simulated sampling and of Markov chains. Through simulation he produces not only the expected amount of production for the agency for the specified year but also develops a distribution table of production as well. This permits the manager to predict in advance, for example, what proportion of the newly created agencies is going to fail according to some specified criterion of success.

Mention was made of a paper by Ed Lew entitled "The Model for Sales Success in an Agency." Using data obtained from a survey conducted by Roper Associates, Mr. Lew develops a simple stochastic model for sales which might aid agents in determining how to use their time most effectively, that is, depending on certain characteristics of the prospect, should the agent make the second recall, the third recall, and so on, or should he spend his time approaching new prospects? He also suggests a more complex model based on a Markov process with several absorbing states and a number of nonabsorbing states.

Mr. Jack Bragg has written several papers on this subject. His first article was entitled "Prices and Commissions Based on the Theory of Games"; the more current article is "Prices and Profits." His articles are of particular interest because of his use of the theory of games in seeking an understanding of the interaction between prices and commissions. Mr. Bragg's papers are an attempt to give us a new approach and insight into this problem.

In the area of investments there does not seem to be much evidence, at least in terms of publications, that insurance companies are making their portfolio selection solely on the basis of a computer model. Companies are using computers to help them evaluate their portfolios or to produce information as a basis for their decisions. For example, an article in *Business Week* (May, 1968) indicated that a number of investment companies were programming their computers to write up a list of stocks with five-year earning growth *greater* than the market as a whole but coupled with price earnings in a ratio less than the market average.

Although there has been interest in the Markowitz model and the simplified model of William Sharpe, which lists alternative minimum risk portfolios for a stated level of desired return, few companies are using the model in their day-to-day operations. This appears to be a fertile field for research.

In the area of determining premiums and retention limits, a number of articles have been written. I think that anybody who wants to become indoctrinated in the area of simulation certainly should read the article by Sidney Benjamin, "Simulating Mortality Fluctuations." His article is an excellent starting point and guide for anyone who is going to simulate the mortality experience of his company. Russell Collins, of course, also has written several articles. One of these is entitled, "The Simulation Model of Life Insurance Company Reinsurance Pools," in which, through simulation, he evaluates various reinsurance schemes, proportional and nonproportional.

Douglas Sanders has contributed several papers of value. His article "Investigating Individual Life Reinsurance Retention" is one of particular interest, as he extends Mr. Benjamin's simulation schemes to problem situations involving two decrements. Mr. John Boermeester has made some valuable contributions, including the first article on an insurance application of the Monte Carlo technique. At the Duke Conference on Simulation he read a paper on "A Russian Roulette and Splitting Simulation Model." These techniques are more efficient, for example, in terms of computer time in establishing a distribution of claims when analytical modes are not appropriate. Karl Borch has written a number of articles which will be of interest to a number of you. He has suggested various models based on the utility theory approach.

In the area of corporate models a great deal of literature exists. For those of us in the insurance industry, articles by John Hogan would be of particular interest. In long-range planning, a dynamic model of a system that can be manipulated on a computer to give a faithful replica of the real world system can be a very valuable tool.

In a miscellaneous group I would include Dwight Bartlett's article on "Optimizing Debit Size: An Operations Research Study." A mathematical model was developed, using termination rates of agents, length of time that the debit stays open, and production and termination rates of business as dependent variables. The number of debits into which a company's operations would be divided was used as the independent variable. The object of the study was to determine which value of the independent variable would maximize the profitability of the company.

Finally, I would like to call your attention to an article which appeared in the *Journal of Risk and Insurance*, by A. E. Hofflander and Milton Drandell, entitled "A Linear Programming Model of Profitability Capacity and Regulation in Insurance Management." Although the article pertains to property liability insurance, I believe that you will find it an interesting application of linear programming.

I would like to comment next on the question of why a company should have a computer model. Of course, one answer is that it makes it more feasible to apply operations research techniques and to consider a large number of variables without making the time and effort involved prohibitive. I do not believe, however, that we are including more variables in our models simply to appear sophisticated or to impress someone that we have a very elaborate model. I think there are some good reasons for this. The fact that we are interested in equity products and holding companies causes us to consider a number of economic factors as well as the traditional ones, such as mortality rates, lapse rates, termination rates, and the like. We are learning from the economists that, if we are to develop a meaningful corporate model, our model must include exogenous as well as endogenous variables. Another reason that we are including more variables in our models is that we are learning from the social scientists how to quantify variables that we previously considered qualitative in nature only.

In many cases, the investigator cannot obtain an analytical solution because of the complexity of the problem, lack of knowledge of some of the variables under consideration, or an unawareness of *all* the variables which need to be considered. Also, our previous speaker cautioned us that in some models the parameters may be a function of time. If this is true, it certainly adds to the complexity of the model and would make computer simulation more desirable.

I would like to conclude my remarks by quoting from an article by W. Earl Sasser and Thomas H. Naylor, entitled "Computer Simulation of Economic Systems."

Looking first at the observation stage of the scientific method, we find frequently in economics that it is either impossible or extremely costly to observe the actual behavior of an economic system. For example, certain historical data, such as sales data, cost data, and production data may simply not exist for a particular business firm. However, we have sufficient information to formulate "meaningful" hypotheses about the probability distribution of some of these variables over time or estimates of their trends over time. We may then use a computer to generate data (pseudo-observations) for the economic system of interest on the basis of the assumed probability distributions or time trends. The pseudo-observations may in turn be used by the analyst in formulating, manipulating, and testing models describing the behavior of the system as a whole. That is, we merely substitute the computer generated data for the missing actual observations of the economic system. In many cases this simulated data may prove to be completely adequate, particularly if the model of the economic system under study is sensitive only to large changes in the magnitude of the values of the simulated input data.

Models used in the development of theories of the business cycle and market behavior both give rise to difficulties of this type. Since the 1930's economists have relied on solutions to differential and difference equations as the standard analytical techniques for investigating the behavior of business cycles and competitive markets. But as nonlinearities, higher order equations, and stochastic variates are introduced into these models, solutions by straightforward analytical techniques become increasingly difficult, if not impossible. Although it may be conceptually possible to formulate a mathematical model describing the behavior of a dynamic multiprocess firm operating under uncertainty, present day mathematics is simply incapable of yielding solutions to a problem of this magnitude. Under these circumstances economists have almost been forced to turn to numerical analysis.

In summary, computer simulation provides us with a tool for tracing out the effects of alternative decision rules and policies on the behavior of an economic system within the confines of a tightly controlled laboratory experiment. With computer simulation we can experiment with more variables, more decision rules, more complex models, and models which more nearly approximate the actual behavior of economic systems, and we can do all these things with speeds which were heretofore unattainable.

BIBLIOGRAPHY

Bartlett, Dwight. "Optimizing Debit Size: An Operations Research Study," *TSA*, XX, 169.

———. "The Simulation of Model Agencies Using Monte Carlo Methods," *Proceedings of the IBM Symposium on Operations Research with Insurance Industry*, August 17, 1966, Los Angeles, California.

Benjamin, S. "Simulating Mortality Fluctuations," *Transactions of the 17th International Congress of Actuaries*, Vol. III, 1964.

Boermeester, John. "Frequency Distribution of Mortality Costs," *TSA*, VIII, 1.

———."A Russian Roulette and Splitting Mortality Simulation Model," Duke University Actuarial Conference on Simulation, October 31–November 2, 1968.

BORCH, KARL. "Some Elements of a Theory of Reinsurance," *Journal of Risk and Insurance*, XXVIII, No. 3 (1961), 35.

BRAGG, JACK. "Prices and Commissions Based on the Theory of Games," *Journal of Risk and Insurance*, Vol. XXXIII, No. 2 (June, 1966).

———. "Prices and Profits," *TSA*, XX, 44.

COLLINS, RUSSELL M., JR. "Actuarial Application of the Monte Carlo Technique," *TSA*, XIV, 365.

———. "A Simulation Model of a Life Insurance Company Reinsurance Pool," Actuarial Research Conference, University of Michigan, November 14–16, 1966.

HOFFLANDER, A. E., and DRANDELL, MILTON. "A Linear Programming Model in Insurance Management," *Journal of Risk and Insurance*, Vol. XXXVI, No. 1 (March, 1965).

HOGAN, JOHN D. "Long-Range Planning," *TSA*, XVIII, D305.

———. "The Use of Operations Research in Field Planning," *Proceedings of the IBM Symposium on Operations Research with Insurance Industry*, August 16, 1966, Los Angeles, California.

LEW, EDWARD A. "A Model for Sales Success in Agent-Prospect Encounters," Duke University Actuarial Conference on Simulation, October 31–November 2, 1968.

MARKOWITZ, HARRY K. "Portfolio Selection," *Cowles Foundation Monograph 16* (New York: John Wiley & Sons, 1959).

SANDERS, DOUGLAS O. "Methods of Simulating Random Components of Life Insurance Financial Results," *Journal of Risk and Insurance*, Vol. XXXV, No. 3, 1968.

———. "Investigating Individual Life Reinsurance Retention," Duke University Actuarial Conference on Simulation, October 31–November 2, 1968.

SHARPE, WILLIAM F. "A Simplified Model for Portfolio Analysis," *Management Science*, Vol. IX, No. 2 (January, 1963).

MR. ROBIN B. WELCH: Being basically a pragmatist in this field of computer modeling, I think it might be helpful if I concentrate my discussion on one particular application, which just happens to be New York Life's company model. I hope to show why we are using a computer model, what we are already using it for (and what we intend to use it for), and what dollar and personnel commitment is required to develop such a model.

To begin with, this model really consists of about thirty-five submodels, each of which is a separate, independent model. For example, one of our submodels is the in-force submodel for ordinary life insurance. This model receives new issues from the ordinary life sales submodel. It then proceeds to project the in force for sixty separate years of issue by applying rates of death, surrender, lapse, maturity, and so forth, to each of the sixty years of issue. This means that sixty death rates, sixty surrender rates, and so on, must be applied for every year that we run the submodel. As you can see, the only way that we could ever run such a submodel for fifty, or even twenty, years with different sets of rates is to computerize it. And, as I said, this submodel is one of thirty-five such submodels and is fairly representative as a submodel.

Although the in-force submodel does require many calculations, it still is not nearly as complicated as it could be. For example, it could be done by issue year, plan, and age. And it may eventually be done that way.

By the way, one of the significant advantages of using a submodel approach, as we have done, is that a submodel can be totally changed in concept, and, as long as it produces the same output, it will have no effect on the other submodels.

Another indication of the size of our company model is that it has taken about *30,000* FORTRAN cards to program it.

We think that we are on the right track by having such a relatively complicated company model. We feel that a much simpler model will not give us results that we can have confidence in. And one of the virtues of computer modeling is that there is virtually nothing, no matter how complex, that cannot be simulated. Our original aim was to experiment with the model with the hope that the experimentation would reveal ways in which we could condense the model. Frankly, I have my doubts about this, since it seems to me that, whenever we put one of our submodels under close scrutiny, we always decide to expand it.

Now let me say something about why we decided to develop a company model. We wanted something that would help the company in its long-range planning. A company model can assist in setting goals for the company, or it can assist in showing ways in which these goals can be met. The beauty of a computerized company model is that it enables us to quantify these goals or the means of reaching them. For example, we can see what the assets, liabilities, and surplus might be after twenty years, based on these goals or means of reaching them.

Notice that I did say what our assets, liabilities, and surplus *might* be after twenty years. We do not think of our company model as being capable of predicting the future. Probably the best example of this is that we simply input new-money rates. But, on the other hand, we can run the model for twenty years under high interest assumptions, low interest assumptions, or average interest assumptions. We can also introduce random elements into the interest rate assumptions. In other words, we can determine a range of results that would arise from a particular course of action.

This brings up the point that one must always be sure to evaluate computerized results critically. There is a tendency among some people to accept computer results without question. On the other hand, there may be certain sophisticates (otherwise called actuaries) who would hesitate to accept any computerized results. Be that as it may, common sense, and to some extent intuition, must play a role in evaluating computer results.

I do not want to overemphasize the negative with respect to our company model. We know that it is not perfect and that it will continue to go through a period of revision and improvement. Despite any shortcomings that our model may have, I think it is safe to say that it is the best aid to long-range planning that we have developed so far in our company.

During the time that we were designing and programming our company model, we were operating in something of a vacuum. By that I mean that we knew we would eventually attempt to answer management's questions, but we did not have any questions to answer, nor did we even know what questions might be asked. We could ensure that the programs were working properly by reproducing prior years' results. We attempted to validate the submodels by running them for fifty years to see what inconsistencies resulted. But there is nothing like the pressure of having to produce results that others are interested in. It does make you examine your models critically.

We recently did get a question to answer. The problem began as the question of how many agents should be recruited in 1969. Then the scope of the question was expanded to include determining what our level of agent recruitment should be for the foreseeable future. We decided to use the company model to help answer this question. We ran the ordinary sales, in force, reserves, and premium and commissions submodels for twenty-year periods, using different levels of agent recruiting, agent persistency, and sales per agent.

As the results were produced and evaluated, the question began to evolve. We began to think in terms of a certain percentage increase in new business every year. Now we are looking at the other side of the coin and are investigating how many agents we have to hire in order to produce this percentage increase in new business. Company models and management games seem to have this tendency for getting people to think in terms of goals. Another good example concerns the life insurance management game originally developed at Minnesota Mutual and later extended at New York Life. Our summer students have played this game for the last three years. It is not at all unusual for them to ask our actuaries, "What are New York Life's goals?" As you might imagine, this is not always the simplest question to answer.

The value of using common sense in evaluating computer models is showing itself here. Specifically, it makes no sense to assume in a sales model an increase in agent recruiting that cannot be supported in the real world. Not only must there be an adequate pool of prospective new agents from which to choose, but there must be enough recruiters to find these individuals and enough sales offices to which they can be assigned.

Also, in trying to help answer this evolving question, we have found ways in which these submodels could be improved. One example is in the case of the sales submodel, where we will in the future base the number of agents being hired on the number of recruiters and the number of sales offices. And the recruiters will probably be related to the agents hired in the last five years, since that is the prime source of our recruiters.

A second application of our company model is in the case of our five-year projection. The five-year projection is done each spring and is an attempt to estimate the company's financial results for the next five years. Up to the present it has been hand-calculated for the most part. This spring for the first time we have used our company model to do the five-year projection.

Using the company model to do the five-year projection is not too surprising when you discover that our company model is to some degree an extension of our hand-calculated five-year-projection techniques.

One advantage in using a computer model is that you can change your assumptions rather easily. After having run many of these submodels, we decided that we did not like our surrender rates. We were able to rerun thirteen of our models in less than two hours of IBM 1130 computer time. In the past, we would have had to make approximate changes in our results because of a change in the surrender rates. I cannot honestly yet say that our five-year projection is any better for having used the company model, but at least I can say that we ran it more often.

So far I have tried to explain what our company model is and what we have already used it for. Perhaps by now you would be interested in what dollar and personnel commitment was needed to produce this model. I once attended a seminar at Columbia University in which one of the speakers said that he had never seen a successful computer simulation done for less than $25,000. If this were the only criterion for success, you would call our simulation successful.

Most of the work in the designing and programming of this model was done in 1968. During that year we had one actuarial student assigned full time to it. We had nobody else working full time on the model, but we had much part-time help. Seven different people designed one or more submodels. Eighteen people (including five of those who designed submodels) wrote one or more programs. Of the eighteen people who wrote programs, four were summer actuarial students. Another three were actuarial students who were with us for three or four months between college and the army or the Public Health Service.

Other sections of the company often were not too eager to take these people who would be with us temporarily. But they fitted in perfectly with our plans. We had submodels that had been designed but had not been programmed, and there was no one else available to program them.

The other people who programmed the company model were people who were working permanently for the company but who could only devote part-time effort to the model. Generally, it would work out that these people would program the submodels for two or three weeks full time and then debug their programs on a part-time basis while working on other projects.

As you can see, we were willing and able to use almost anyone we could get to help us with our programming. We found that we could use such relatively inexperienced programmers if we had well-defined and well-designed submodels and if we maintained fairly close supervision over them. It also helped very much that we required all our programmers to reproduce at least two actual years' results.

My estimate is that we had the equivalent of one actuary, three actuarial students, and two college-educated research analysts working on the company model during 1968. The total salaries involved added up to perhaps $85,000, but I should emphasize the fact that all but one of the people involved in designing and programming the model were working on it part time. Consequently, in many cases these were salaries that would have been paid anyway, and we were simply able to use the people more efficiently.

We also were a major user of the IBM 1130. Our 1130 cost about $1,600 a month to rent, and we were using about one-fourth of its available time. The total cost of computer plus operator time was about $8,000.

Of course, we will continue to refine our model, and that may cost another $20,000 a year.

Perhaps a commitment that is just as important as a dollar and personnel commitment is a commitment to get the computer model done. If it does not have high priority, it may never get off the ground. In fact, with a model the size of ours, it might be worthwhile using PERT. Although we did not use PERT, we did make up time schedules that we tried to stick to. We had a target date of Labor Day of 1968 to complete the programming of these submodels, at least with card imput if not disk output from other submodels. We then spent the remainder of 1968 integrating the submodels and validating them.

To sum up, we have a company model that we feel will help us greatly with the company's long-range planning and, incidentally, will also do most of the gory details of our five-year projections. Although there is an undeniable cost involved in building such a model, I believe that it has to be looked at as an investment cost in long-range planning.

Having discussed our specific model in some detail, I would like to close on a more general note. I attended the Actuarial Conference on Simulation held at Duke University in the fall of 1968. I was struck by the fact that many of the nonactuarial guest speakers mentioned the fact that we, as actuaries, were in a nearly unique position with respect to computer modeling.

Why is our position unique? For one thing, our business is built on mathematical models, and we have the technical background to use them. We probably have more good data available to us than almost any other potential computer model builder. And, perhaps most importantly, we are either part of top management or we report to top management.

Up to now, much of our computer modeling has taken place in the area of risk theory. We have not done nearly as well in such areas as the company model I have been speaking about. But it looks as if times are changing and that we are beginning to take advantage of our unique position.

MR. JOHN W. LINCOLN: Did the summer students you hired know how to program when they came into the company?

MR. WELCH: We managed to pick those with programming knowledge from the twenty to twenty-five summer students hired by the company.

MR. LINCOLN: Did they program in FORTRAN?

MR. WELCH: Yes.

MR. LINCOLN: If you had not had any who knew FORTRAN, would you have considered it worthwhile to teach them programming?

MR. WELCH: Yes. One employee, who was drafted within four months after being employed, came with no knowledge of FORTRAN and only a little knowledge of ALGOL. He was one of our most productive people.

Programming requires a certain knack that some people have and others do not. Therefore, it is possible to train someone with this knack to program adequately within two weeks or a month.

CHAIRMAN BURTON D. JAY: Our experience is similar. We hire from four to eight summer students each year. A few of these are able to begin programming within a few weeks simply bygoing through IBM's selfteaching manual on FORTRAN. Some, if they have programming talent, become quite good at it very quickly.

MR. MICHAEL C. ALTSCHULER: Mr. Welch, were there any major inconsistencies in trying to put together your many submodels?

MR. WELCH: Not really. We designed our submodels so that they would fit together in one large company model. We were well aware that we had to have output from submodel A to serve as input to submodel B. Submodel A itself might not produce good output, but at least we knew that it had to produce input for submodel B.

MR. JOSEPH P. McALLISTER: Did you imply that you have separate submodels for your insurance in force and reserves rather than taking the output of your in-force projection and valuing it?

MR. WELCH: Yes. We do take the output from the in-force submodel and use it to project reserves in our reserve submodel. Since we do not have the in-force submodel projected by issue year, plan, and age, we cannot put it through our regular valuation.

MR. ABRAHAM HAZELCORN: In your five-year forecast do you assume a flexible relationship in your dividend formula? Do you assume some lag between your dividend formula and your experiences from the combined model?

MR. WELCH: That happens to be fairly simple to answer. One of the main reasons for doing the five-year projection is to determine what our dividend formula will be. Therefore, we keep the dividend formula constant, and we produce our gains by source; then it is up to our management to decide what they are going to do with these gains. We do not, therefore, have an automatic feedback which changes the dividend formula.

MR. LEWIS: There are many small and middle-sized companies represented here today that could not develop a company model such as this. In your opinion, could an industry committee come up with a model for a company that could be used by many companies?

MR. WELCH: It seems to me that, in the case of a model such as ours, it is probably a little too ad hoc to be of general use. The answer is probably "Yes," but I do not know whether you can get an industry committee to support it.

One thing that I think can help the small company is the management game I mentioned. The management game is not a company model, but as a management game it is quite good. It is available at a small cost to anyone who writes to Dave Halmstad at Metropolitan.

CHAIRMAN JAY: As another example, LIAMA has a manpower model which projects amount of sales and size of agency force based on whatever assumption a given company wishes to make as to turnover rates, recruiting rates, and average production rates. This is available for any company, I think, for some fee. One can send whatever input assumption he likes, and LIAMA will return the results for any number of years into the future.

We will probably see more and more general models such as this available on an industry-wide basis.

MR. ANTHONY J. HOUGHTON: Nelson and Warren, Inc., has developed a model company projection using the IBM 1130 computer, which projects the gain from operations showing all the major income and disbursement items, the insurance in force, assets, and liabilities based on the company's actual in force represented by as many cells as thought necessary and new-business assumptions. Each plan, year of issue, and age at issue cell requires specific information, which is recorded on a format sheet. Certain total company information is also required. This preparation of input data is the major cost of the model company projection, so combining of ages and of plans with small amounts of in force is customary. The cost of the actual computer time is quite inexpensive.

A new, small company with the bulk of its in force on two or three plans can produce good results by filling out format sheets for thirty or forty cells plus total company data. Once this input is available, then variations in assumptions on lapse rates, interest rates, new business, and the like, can easily be introduced to demonstrate the effect on profits, in force, assets, and liabilities.