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A Review of the I. B. M. Symposium on Operations Research in the Insurance Industry

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(Editor's Note: In August 1966 IBM held a symposium on the application of Operations Research techniques in the insurance industry. The papers presented have been published in Proceedings—Symposium on Operation Research in the Insurance Industry. *Any reader who wishes to obtain a copy of the* Proceedings *should contact the nearest IBM office.)*

With a background in mathematics not extending beyond that offered in a solid undergraduate curriculum plus that additional amount necessary to pass the Society's examinations, this reviewer was initially somewhat apprehensive about approaching the subject of Operations Research. Each article is so well written and each experiment so adequately described that the apprehension disappeared. Any actuary should find the reports presented well within his grasp.

This review describes, in brief, each of the articles in the volume with some comments.

An Over-view

The lead article by Dr. Eli A. Zubay, *A Survey of Operations Research Techniques in the Insurance Industry and Their Future Potential,* describes the term "operations research" as "the application of scientific methods to problems involving a blend of men, machines and resources." He expresses it as a philosophy of management, rather than a collection of techniques, emphasizing a "multidisciplinary approach to a problem stressing overall objectives of the company."

A major portion of the article discusses, in general, several of the mathematical and statistical tools used in Operations Research and the various mathematical techniques utilized, and sets the stage for the more detailed reports of projects contained in the remainder of the book.

Field Planning

In his account of *The Use of Operations Research in Field Planning,* Dr. John D. Hogan describes what is perhaps the most sophisticated mathematical model of a company and agency currently being used anywhere in the industry. The agency or field model aids the general agent with his financial planning and also generates input to the total company model. This provides home office management with quantitative information which can be utilized as a basis for selecting the best of alternative courses of action.

The agency model relates expenses (agent development, sales assistance, promotion, etc.) to profit of the agency so that the general agent has some objective basis for deciding how to allocate his resources.

The company model uses, as input, data from the agency model as well as other data germane to the company's operation. This projects operating gains and changes in assets and surplus in future years resulting from following a specified plan.

Of all the projects presented this perhaps is the most complicated and most demanding of effort from the reader. Several pages of mathematical formulas used are given in the appendix, but it is not necessary to follow these in detail to acquire a general understanding of the models and their uses.

Manpower and Production

Norman L. Vincent outlines *Manpower and Production Projections with the Use of A Computer Model.* This article describes very clearly his model agency force in such a way that one with little technical training could construct a similar model, given the appropriate basic data. This could be a good approach for a company just beginning an Operations Research effort and wishing to study the relationship between recruiting, retention, and average production rates and the effects of these factors on future field force size and future total production.

Agent's production and termination rates were classified by calendar years of service based on the experience of a hypothetical operation. High, medium and low manpower and production projections were calculated by applying standard error intervals to linear estimates in order to project for future years probable ranges of agency force size and total business produced.

Mr. Vincent concludes his article by describing future expansions of the study, such as building financing costs into the model to project agency financing development costs and adding persistency rates to predict in force figures over a period of time. He also suggests the projection of personnel, building, and equipment needs in the future based upon gross policies in force. The computer easily handles the formidable amount of calculation required.

In his article on *Linear Programming for Life Insurance Problems,* Nathan F. Jones first describes the technique of linear programming and amplifies the description through a simplified problem. This involves the selection of the optimum number of agents and brokers in order to maximize the resulting value of new business produced, subject to the "constraints" of a specified maximum number of brokers and agents, minimum amount of new production and minimum amount of surplus depletion resulting from the production. The illustration gives the reader a feel for the general nature of this very powerful technique.

Other uses of this method are briefly described, including the construction of a representative model office to use for projecting reserves and a procedure used by one company to prepare "needs programs" for the prospects of its agents. These last two examples have a sufficient number of "constraints" or limiting specifications and "activities" or independent variables so as to require the aid of a computer. The reader is left with the feeling that, with a little imagination, many types of practical insurance problems could be studied with this method.

Model Agencies

The article on *Simulation of Model Agencies Using Monte Carlo Methods,* by Dwight K. Bartlett, III, is a most useful illustration of the application of the Monte Carlo technique to a "Markov chain transition matrix" to produce not only expected value projections but also probability ranges. First, a table is described which expresses the probability that an agent will terminate or produce at a given level based upon his production during the previous year. This is called a Markov chain transition matrix. Random numbers are generated and applied to the probability matrix to simulate the production experience of a single agent from year to year until he terminates. This can be done for a set number of agents considered as representing an agency; for each such trial of the specified agency force the number of agents surviving and the resulting production are found for each of several future years.

From the results of several trials or repetitions of the simulation of the agency, Mr. Bartlett was able to prepare several distribution tables showing the status of the agency at the end of its first five and first ten years of operation according to size of agency force, new business written and total business in force from the agency. The proportion of trials resulting in agency production and in force at several specified amount levels and agency size at various manpower levels are shown at the end of the five and ten-year periods, as well as the averages for all trials. From this can be developed the probability that, at the end of the period of time studied, the total agency size, production or in force is within a given range. Averages can be interpreted as expected values.

Mr. Bartlett also introduces expense data and income data as a function of production in order to study the return on the investment made in recruiting or in forming scratch agencies. Illustrations are given of the many types of questions for which the model would provide information.

Home Office Application

The article on *Operations Research Applied in the Home Office,* by Gordon D. Shellard, describes an Operations Research approach to a home office administrative problem. No clearly categorized mathematical technique is used here, although the approach has many characteristics of mathematical programming. This emphasizes, as Dr. Hogan remarks in his article, that Operations Research is "problem oriented and not technique oriented." The problem is to find a staffing rule and an overtime rule for the Underwriting and Policy Issue Departments so as to reduce the backlog of pending policy applications and the resulting delays in issuing policies, without allowing home office costs to rise above an acceptable level.

The situation is broken down into its component parts of process time, waiting time, backlog, staff size, overtime, and work rate. A mathematical expression is thus devised for the backlog at a given time, t_2, and output between time t_1 and t_2. Several alternatives of staff size and overtime rules are plotted in such a manner as to show the result in process time and cost per application. Several other similar functions are also plotted. Management is thus provided with valuable information as a basis for a decision.

This study was one of the earlier applications of Operations Research to an insurance problem and was probably not thought of as Operations Research. Mr. Shellard discussed this study at a Society meeting in 1965 (see *TSA* XVII, D 312 et seq.).

Portfolio Analysis

The discussion on *Portfolio Selection and Security Analysis,* by Milton Drandell, provides some of the details of two of IBM's investment systems which are now in use, one dealing with portfolio selection and the other with security analysis. The main tools used are mathematical programming and statistical analysis.

The Portfolio Selection Program assists the manager in planning and optimizing an investment strategy. It is based on a mathematical theory developed by H. M. Markowitz. The program strives to minimize risks, expressed as the variance of the rate of return (a random variable of the model) for a given expected level of return. Effect is given to various constraints imposed upon amounts to be invested in individual securities.

This is a creative application of a quadratic programming approach. From the data assembled and with the use of some elaborate formulae, the computer calculates the proportion of assets to be invested in each security for the maximum and minimum possible expected portfolio return and several levels of return in between, such that all linear constraints are adhered to and the variance of the portfolio return (the risk) is minimized.

The IBM Security Analysis Program provides information upon which input decisions for the Portfolio Selection Program can be based. A number of reports for individual securities can be prepared based upon data stored in the computer or on a magnetic tape file. These reports include a list of companies meeting specified standards, past data and ratios for individual companies, and financial and market information for a number of companies.

These two systems represent approaches which will undoubtedly be refined and expanded in years to come and which will provide those responsible for making investments with more detailed information on a more timely basis than could have been imagined a few years ago. This subject was also touched upon in the Operations Research Panel Discussion *TSA* XVII, D 307 et seq.

This volume could well become a major reference for those involved in our infant Operations Research efforts and it is strongly recommended to any actuary who would like to become acquainted with this new tool. One project for the Committee on Continuing Education, proposed by the Walter Klem Committee, could be to assemble an index of all known Operations Research projects involving insurance applications which have been reported in any publication. The index could give a summary of the nature of the project. □

NOTES FROM PHILADELPHIA

Printing troubles delayed the mailing of the papers to be discussed at the Spring meetings. Despite the short time elapsing between receipt of the papers and the Philadelphia meeting there were some good discussions. The papers can still be discussed even though the discussant will not necessarily be in attendance at either of the two later meetings. A copy of any discussion should be sent to the author and three copies to the Secretary. □