DISCUSSION BY LESTER B. DROPKIN

The primary objective of this Society is the promotion of actuarial and statistical science. The furthering of any science, including our own, requires not only the discovery of new facts, new theoretical utilizations of formulas, and the exploration of new areas, but also requires the effective communication and transmittal of the results of such research. An aspect which, unfortunately, can too often be overlooked.

The vast number of papers, representing countless hours of intensive work and thought, which have been presented before this Society and which recite the discoveries of the various authors, are eloquent testimony to the manner in which the membership of this body has responded to the first requirement for the promotion of actuarial science. Until the appearance of Mr. Simon's present paper, the second requirement has been something less than wholly fulfilled. The paper by LeRoy Simon stands almost uniquely alone in having as its purpose the presentation of an introductory bibliography on a particular subject area, the subject here being the negative binomial and its applications. The Society should indeed be appreciative of the extremely valuable contribution which this paper makes to our common objective.

The bibliography, and the paper itself, is organized according to several distinct areas: Fundamentals, Early Origins, Applications, Models and Advanced Topics. Within each of these areas, Mr. Simon brings together a number of particularly appropriate references from books, articles and papers. Mr. Simon, however, does much more than merely supply us with organized reading lists—although even if he had done only that it would have been of great value. The special distinction of this paper arises out of the fact that Mr. Simon has given us a real guide to these papers and books through the use of judicious and pertinent comments on each reference. As each reader brings to the paper his own personal background and range of interests, each will find that particular area which is most valuable to him.

In many instances, a reviewer of a bibliography feels freely entitled to suggest that references A, B, and C should be deleted, while references X, Y, and Z be substituted therefor. Although it is the case that this reviewer, had he undertaken the compilation of a bibliography, would have omitted some of the references and added others, the fact is that Mr. Simon has taken the task on himself, while the reviewer has not. This reviewer feels therefore that in the absence of any major disagreement with respect to the references cited, it would only overstep the boundaries of responsible criticism to interject personal opinions and preferences.

One of the difficulties in working with the negative binomial is that it may arise out of two entirely dissimilar processes. Mr. Simon has, of course, mentioned this several times in the paper. Nevertheless, and in order to avoid any possible misinterpretation, Mr. Simon could have more strongly stressed the fact that the two approaches are not merely "alternatives" in the sense that, say, calculating a rate level change by the loss ratio method is an "alternative" to using pure premiums. The two processes are, rather, "alternatives" in a much more fundamental sense. The negative binomial, viewed as a compound Poisson, assumes independence from trial to trial. On the other

hand, the assumption of independence is incompatible with the "contagion" process, the second avenue of approach to the negative binomial. An excellent opportunity to explicitly bring out the difference between the two approaches was afforded when Mr. Simon set out the two models for generating the negative binomial. It was, therefore, somewhat disturbing to see Mr. Simon characterize the second model as being only "a more elaborate model" than the first.

Mr. Simon closes his paper with the remark: "There is a great deal of exploration and application yet to do and I hope our Proceedings will contain much of the good work in the future." There is no doubt in my mind that Mr. Simon's paper will be an essential instrument in making possible this hoped for future.

DISCUSSION BY LEWIS H. ROBERTS

We are favored to receive this bibliography on the negative binomial distribution, all the more so for its concise resumes and evaluations of references. The value of this work is much enhanced by the authors well conceived selectivity in choice of entries since so many discussions have been published on this distribution and on the related subject of accident proneness. The student who attempts to survey the entire literature is confronted with a large number of sources, many being redundant, some misleading and some irrelevant to insurance problems. The first work mentioned in this bibliography, for example, lists eighty four other references!

A point made by several writers, and properly emphasized in this paper, is the danger of estimating rate differentials from the negative binomial parameters derived from the distribution of risks by the number of claims incurred during a single period of experience. The negative binomial can arise from other causes than heterogeneity of risks, and the apparent degree of heterogeneity can be distorted by other factors.

Even the use of a bivariate negative binomial with two periods of experience does not necessarily lead to proof of heterogeneity since, as pointed out, interdependence of accidents can also yield that distribution.

The author mentions a paper by Edwards and Gurland which, because of its particular attention to the treatment of experience for separate time intervals, should be of special interest to actuaries. They show, first, that such experience can sometimes be well represented by a bivariate negative binomial. They next develop a more general function of which the negative binomial is a special case. As might be expected because of its greater generality, the latter distribution may give a better fit than the former, but at the cost of introducing at least one additional independent parameter. I hope a shorter name will be found for this distribution. These authors call it a "compound correlated bivariate Poisson."

With the mathematics of general insurance in its present stage of development, there is no ready formula for every problem. If he is to be more than just a theoretician, the actuary must draw upon the a priori knowledge provided by practical experience. The existence of classes with consistently dissimilar loss experience conclusively demonstrates that heterogeneity does exist in the general population of risks. To suppose that this characteristic