DISCUSSION BY JOHN C. WOODDY

Mr. Simon has written an interesting paper which reveals itself to be more a collection of ingenious manipulations of assumed relationships than a set of directions for calculating catastrophe reinsurance premiums.

The key sentence is in Section 2. It reads; "Attention will be focused on situations where it will be appropriate to assume that any loss which hits the cover will run all the way through it, that is, all losses will be total losses." This assumption is not commonly used in catastrophe reinsurance of life portfolios, and I understand that it is not the European practice in non-life catastrophe reinsurance. However, the assumption does have the consequence that the same mathematical results can be obtained by considering one death, two deaths, etc., among a group of lives, each having the same probability of death and the same amount of life insurance. This allows the usual risk theory assumptions of independence, stationarity and exclusion of multiple events to be made, so as to permit use of the Poisson distribution to specify the probabilities of a given number of deaths.

Using the expected number of claims of examples A and C in the paper, namely .09553, the sum of the probabilities of 0, 1, 2, 3, and 4 claims is equal to .999999, that is, practically all of the probability. As indicated in the paper, the pure premium to cover one payment of $9 million, in the event that at least one claim occurs in the year, is $819,981. Furthermore, the pure premium payable in advance to provide for payment of $9 million on the first claim plus another $9 million if there is at least one more claim during the year, is $858,528. However, the pure premium payable in advance to provide a payment of $9 million on each claim without limit on the number of claims is only $859,770.

I think that, psychologically, we are prepared to accept results like this when dealing with four lives each having a probability of death of about 2.4% where we know that the life either fails or does not fail. I do not feel equally comfortable with only a little more than $1,000 difference between the unlimited cover and the two-event maximum discussed above when catastrophe claims are, in fact, characterized by severity as well as frequency. I guess the question that I am really raising is whether catastrophe reinsurance priced under the assumption of "all losses will be total losses" provides a good framework for illustrating consistency of pricing.

Another point which calls for mention in the examples in the paper is the reference to provision for "overhead and profit". Of course, we may take it that the provision for profit includes the security loading, or provision for the risk of adverse fluctuations, but I must say that I would have expected a larger percentage of the gross premium than those suggested in the examples. I would expect a security loading to be a function of the standard deviation and/or the variance of the distribution of catastrophe claims.

Mr. Simon mentions that if the assumption that "all losses will be total losses" causes difficulty, "it may be necessary to apply this model to narrow sublayers of a given treaty". A paper entitled: "Rückversicherung des Kumulrisikos in der Lebensversicherung", by Paul Strickler, in the 1960 *Transactions of the International Congress of Actuaries (TICA)* presented in Brussels gives a procedure for calculating the net premium for a catastrophe cover applicable to a life insurance portfolio. An English translation appeared as item 3 in the first issue of *Actuarial Research Clearing House*.[1] The formulae in the paper require determination of a function $A(y)$, the annual number of deaths per million of general population, from all accidents causing the deaths of y or more persons. Also required is the frequency function for the amount z (limited by the warranted maximum risk on any one life) payable on account of one death in a catastrophic accident, given that such a death has occurred. Since the $A(y)$ function, as used in the premium formula, gives rise to a summation of the costs of one death, two deaths, three deaths, etc., in excess of the number of deaths retained by the ceding company, the total layer covered by the catastrophe reinsurance treaty is, in effect, subdivided into the separate layers defined by the successive numbers of deaths.

Of course, a catastrophe treaty usually specifies the deductible or ceding company retention and the reinsurance limit in dollars rather than numbers of lives. The conversion factor between the two is usually the average amount at risk on a life.

[1] Formula (11) is correct in *Actuarial Research Clearing House* but erroneous in the *TICA*.