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CONCENTRATION OF RISK AND THE CATASTROPHIC ACCIDENT HAZARD

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THE 1953 report by the directors to the policyholders of the John Hancock Mutual Life Insurance Company contained the following statement:

During the year the Company completed a reinsurance arrangement with Lloyds covering certain excess losses which might arise as a result of concentration of claims from such peacetime disasters as hurricanes, explosions, fires, floods, and earthquakes. As our Company grows, it provides protection for an increasing percentage of the population and such a catastrophe might include a large number of policyholders. Increasing amounts of insurance on individual lives could also result in substantial claims arising from a disaster involving a relatively small number of lives.

This excess loss insurance, which applies to all life and accidental death insurance in Ordinary, Group and Industrial business, is designed to minimize the effect of catastrophes on the policyholders' surplus.

It is the purpose of this paper to outline the reasoning behind the introduction of the kind of coverage referred to above and some of the details of the reinsurance arrangement.

The catastrophic accident hazard is an obvious and continuing one. It is brought to prominence occasionally as at the time of the Texas City disaster, the Cocoanut Grove nightclub fire in Boston, the circus fire in Hartford and the series of tornadoes that hit Flint, Waco and Worcester. These are the more spectacular occurrences. However, a review of accident statistics will show that week by week accidents of various sorts are occurring which result in five or more deaths, five or more being the number of deaths generally accepted as defining a catastrophic accident.

There is a tendency to think of the catastrophic accident hazard as being confined to group insurance. The concentration of risk which creates the hazard is undoubtedly greatest in the field of group insurance but is by no means limited to that branch of the business. Many instances of concentration can be found in the Ordinary field. Pension trust, salary savings and broad profit-sharing plans parallel group insurance in this respect. In a large business insurance case an underwriter may limit his company's risk to $200,000 on an individual life but take well over $1,000,000 total on a group of men who work together and travel together

from time to time and who may even play together. Intensive selling may result in concentration of risk even though each sale is independent. An agent may find many of his clients in his office building, his neighborhood and his country club. Centralized agency development within an area, while it may contribute to efficiency, also contributes to concentration of risk. Industrial insurance with its debit method of collection of premiums is inherently a highly concentrated business even though the individual amounts are small.

Four years ago a limited study of concentration of business was made in the John Hancock. It was interesting to note that the concentration varied markedly by branch in different areas. For instance, in one large city 67% of the risk was in group insurance, 30% in ordinary insurance and 3% in industrial insurance, while in another the distribution was 12% group, 56% ordinary, and 32% industrial. Another interesting item was an engineering survey of the plant of a group policyholder employing a large number of people, which showed that because of the layout the concentration of risk was less than for many a group or pension trust case only a fraction its size. The results of the whole study led to the conclusion that the catastrophic accident hazard was common in some degree to all three branches.

Although material is not readily available for a refined measure of the magnitude of the catastrophic accident hazard, a measure of its general level may be obtained from figures published by the Metropolitan Life Insurance Company in its *Statistical Bulletins* and by the National Safety Council in its booklet, *Accident Facts*. During the decade 1941 to 1950 there were about 1,051,200 accidental deaths, of which 13,213, or about $1\frac{1}{4}\%$, are recorded as resulting from catastrophes in which five or more lives were lost. In recent years the nationwide annual accidental death rate has been about 60 per 100,000 of population. Applying the factor of $1\frac{1}{4}\%$ to this figure gives a catastrophic accidental death rate of .75 per 100,000 exposed or a probability of catastrophic accidental death of .0000075. It seems reasonable to assume that, in general, insurance coverage is more widely distributed in those areas where the catastrophic accident hazard is greater, even though the accidental death rate may be lower than for the population as a whole. If the experience among insured lives followed the population statistics and if there were no variation in the probability of catastrophic accidental death by amount of insurance, there would be a net annual catastrophic accident claim cost of $\frac{3}{4}¢$ per $1,000 of coverage.

Although this net claim cost of the catastrophic accident hazard is small, the dollar claims incurred by an individual company may vary

widely from year to year. The application of statistical methods for measuring variation develops much larger indexes of relative chance deviation for the catastrophic accidental death hazard than for the broader coverage of the normal insurance policy of which it is a part. At the 10,000 life exposure level the probable deviation is about 2.42 times the probability for catastrophic accidental death compared with corresponding ratios of 0.30 for accidental death and 0.09 for death from any cause. For 10,000,000 lives exposed these ratios become .077, .009 and .003, respectively. Mr. Rosenthal in his paper on "Limits of Retention" points out that the value of the measure of relative chance fluctuation decreases with increase in N, the number of lives exposed, with increase in q, the average death rate, or with the narrowing of the spread between the maximum and average amount at risk on a life. The probability of catastrophic accidental death of .0000075 is very small compared with the approximate probability of accidental death among insured lives of .0005 and the approximate probability of death among insured lives of .005. While the lower maximum limits for accidental death insurance tend to provide less of a spread between the maximum and average than for life insurance, thereby offsetting to some extent the smaller q and N in maintaining stability of experience, the catastrophic accidental death hazard, being inherent in both life and accidental death insurance, has a spread between the maximum and average per life somewhere between those of the two lines.

The chance fluctuation of the catastrophic accidental death rate when taken by itself is large compared to that of the death or accidental death rates of which it is a part, but it still is a relatively small portion of the chance fluctuation of the whole coverage. The absolute measure of deviation of catastrophic accidental death is about $\frac{1}{8}$ of that for accidental death and about $\frac{1}{25}$ of that for death from any cause. Many causes of death are statistically more important than the catastrophic accident. The relative size of the probability of catastrophic accidental death and even of its deviation are sufficiently small to be absorbed into the experience of the coverage as a whole and would be of little concern were it not for the possibility of concentration of claims. While the chance is remote, a single insurance company could experience losses running into the millions from a single catastrophe.

Even though a loss of such magnitude did not threaten company solvency, it could upset the orderly development of surplus and distribution of dividends by class, especially in a company whose management philosophy expects each class to stand on its own feet with a minimum interchange of surplus. A catastrophic accident can have greater effect in

areas of coverage where the premium or surplus is low in relation to the potential liability, such as accidental death insurance, group insurance, term insurance or newly introduced plans of insurance, or where the dividend class is geographic in nature, as in group insurance.

The above consideration of the catastrophic accident hazard has excluded any reference to the war hazard. I believe that the potential widespread civilian loss of life resulting from use of atomic or hydrogen weapons in time of war is so great as to be immeasurable and uninsurable within practical limits. If the hazard is not excluded literally from the coverage in the contract, it is very likely to be excluded practically through a moratorium on debts if such a major war should ever develop. The ramifications of the effect of an atomic war would extend into every segment of our economy and the problems of the insurance industry would be one small part of the whole. I understand that an industry committee is carrying on a continuing study of our part of the problem and that their work is being coordinated with that of other groups working on other aspects of the problem.

Concentration of risk can be controlled to a limited extent through underwriting and agency development. Underwriting control, as a practical matter, is pretty much limited to the mass distribution vehicles of group, pension trust and salary savings plans where cases situated in concentrated industrial areas can be discouraged on the grounds of existing exposure. Agency budgets can be used to stimulate areas best suited to balance the company's risk while, at the same time, contributing to healthy growth. Practical considerations restrict the amount that can be done in these directions and, even if carried to the extreme, substantial concentration of risk would still exist under today's conditions. Long-term plans for decentralizing industry may have a modest effect in the future but the urban-suburban pattern of living appears to be a permanent feature of our society.

Since concentration of risk and the catastrophic accident hazard cannot be eliminated by practical methods, a life insurance company has the choice of carrying the risk itself or reinsuring all or part of it. The case for reinsurance is based on the remoteness of the hazard and the magnitude of the possible loss. If the risk is reinsured it may be pooled with other remote contingencies outside the life insurance field rather than with the company's regular mortality experience. Since reinsurance of the hazard would remove a potential strain on surplus, it would seem reasonable to charge the cost of the reinsurance against the contingency loading in the insurance premium.

The portion of the risk reinsured is narrowed by limiting the reinsur-

ance to losses within specified maximum amounts in excess of a specified deductible amount and by the original insurer carrying a part of the risk within these limits. Within ranges which maintain a reasonable community of interest between the insurer and the reinsurer, the level of the deductible and maximum amounts and the degree of coinsurance can be set to suit the wishes of the original insuring company as to the portion of the risk it wishes to carry itself and the portion it wishes to reinsure. The portion of the risk reinsured can be further narrowed by making the reinsurance applicable only to a certain branch or branches of the company's business, such as its group insurance, or to a certain class or classes within a branch, such as a single large group case. Incidentally, narrowing the coverage in this way does not necessarily reduce the cost of the reinsurance proportionately. Once the basic charges are met, additional risk can be covered for little more than its very nominal statistical net claim cost.

On the basis of thinking outlined herein, the John Hancock decided to reinsure a part of its potential liability in event of catastrophic accident. The reinsurance covers 90% of $5,000,000 of loss in excess of the first $500,000 arising from each and every catastrophic accident. The aggregate payable in a contract year is limited to $9,000,000. The coverage excludes deaths resulting from war or invasion and any losses in excess of $200,000 on any one life. It applies to all the company's life and accidental death insurance irrespective of the branch in which it may be written.

The scope of the coverage can be illustrated by the number of deaths which would be required in a single accident to exhaust the $500,000 deductible and to reach the $5,000,000 maximum. In the ordinary and group branches our combined limits of retention for life insurance and accidental death benefits are high enough so that the deaths of the five individuals required by the definition of a catastrophic accident could, if they were all insured for large amounts, exhaust the $500,000 deductible amount. On the other hand, it would require the deaths of more than 125 policyholders who were insured for the company average amount to reach the $500,000. In the industrial branch the issue limit is small enough so that if the accident involved only industrial claims the corresponding figure would be deaths of 84 individuals with maximum coverage or about 440 individuals with average coverage. The $5,000,000 maximum per catastrophe would be exhausted with deaths about eleven times these numbers. It is interesting to compare these figures with the loss of life in the larger disasters of recent history. The New England hurricane of 1938 involved 657 deaths, the Texas

City disaster, 561, and the Cocoanut Grove fire, 492. Going further back, about 6,000 lives were lost in the Galveston tidal wave, 2,209 in the Johnstown flood, 1,833 in the Florida hurricane of 1928, and 1,517 in the sinking of the Titanic.

Catastrophic accident is defined for reinsurance purposes as each and every accident or series of accidents arising out of one event or occurrence resulting in the death of five or more individuals insured by the John Hancock. Where an earthquake or windstorm is involved, all disturbances occurring during forty-eight consecutive hours are considered as one accident. In the case of accidental death insurance, any death which qualifies for benefits under a John Hancock policy constitutes an accidental death under the reinsurance contract. In the case of life insurance, any death resulting from accidental drowning, asphyxiation or poisoning or bodily injuries sustained solely through external, violent and accidental means directly and independently of all other causes within twelve calendar months from the date of the accident is defined, for the purposes of the reinsurance contract, as an accidental death.

The premium for the reinsurance was based upon a net annual claim cost of $\frac{3}{4}¢$ per $1,000 of coverage. Reductions were made for the narrowing of the definition of catastrophic accident to one involving the death of five individuals insured by the John Hancock and for the inclusion of the deductible, the coinsurance, and the maximum features. These reductions were necessarily very approximate and the first two were substantial. A reasonable loading for expenses and risk charge was included. Finally the premium was rounded off to a flat charge for the period of the contract without adjustment for changes in exposure. Initially a one-year contract was used, followed by a three-year contract at the first renewal.

Losses of the magnitude reinsured against obviously would not break the Company. The $4,500,000 maximum payable in any one catastrophic accident and the $9,000,000 maximum payable in any one contract year represent only $1\frac{1}{3}$ and $2\frac{2}{3}$ percent, respectively, of the policyholders' surplus funds. On the other hand, they do equal $8\frac{1}{2}$ and 17 percent, respectively, of a year's dividend disbursement to life and accidental death insurance policyholders. If the losses were concentrated in a few dividend classes their significance would obviously be much greater. Since the net claim costs of the catastrophic accident hazard must be met in the long run whether reinsured or carried by the company, the reinsurance contributes to the stability of the development of surplus and distribution of dividends by class at the very nominal cost of the excess of the reinsurance premium over the net claim cost.

DISCUSSION OF PRECEDING PAPER

EDMUND C. BERKELEY:

I am personally grateful to Edward Green for bringing up a subject which I am sure we must all be deeply concerned with, the subject of catastrophic accident hazards. The hurricanes, Carol and Edna, that recently visited New England, and Hazel that visited outside of New England, have again focused our attention on problems of catastrophic accident.

It seems to me wise and far-sighted that the directors of the John Hancock Insurance Company should have reinsured a portion of their catastrophic accident hazard with Lloyds.

Mr. Green derives a rate of catastrophic death equal to about seven per million, and uses this rate as a starting point for calculation of a premium. But he makes me very curious and does not answer my curiosity about the reductions that were made for "the narrowing of the definition of catastrophic accident to one involving the death of five or more individuals insured by the John Hancock, and for the inclusion of the deductible, the coinsurance, and the maximum features." He says: "These reductions were necessarily very approximate, and the first two were substantial." But I have certainly begun to wonder what these reductions were and how the computation was actually made.

Mr. Green determines a catastrophic death rate of $1\frac{1}{4}$ percent of the accidental death rate based on United States statistics for 1941 to 1950. For certain kinds of catastrophes I would be satisfied with the statistics for this area and this period of time, but not for all kinds.

In regard to time, I am not sure that these ten years would be representative of the future. For example, in a recent accident at Chalk River, Ontario, an atomic energy plant, a reactor, apparently escaped from proper control, and a serious radioactive contamination occurred, although, from what I have read, there was no loss of life.

It seems to me that, in the likely future, atomic energy will be used rather widely for power, and more accidents of this type involving scattering of radioactive wastes and other unfortunate events may well occur.

In regard to place, the United States may not be altogether a typical area for many kinds of catastrophic accidents. If we look outside of the United States, we can find examples of rather serious catastrophes of con-

siderably greater magnitude than those on which the seven per million rate is based.

We can conveniently distinguish three classes of catastrophes. The first class consists of natural catastrophes, those caused by an act of nature. Some of the worst of these are the following:

Typhoon and sea wave, India, mainly Bengal, October 31, 1876, over 200,000 persons killed.

Volcanic explosion, Mt. Pélée, Martinique, West Indies, May 8, 1902, total deaths estimated at 40,000.

Flood caused by the Yellow River, Honan Province, China, 1887, over 800,000 persons killed.

Earthquakes, Shensi Province, China, January 24, 1556, more than 800,000 persons killed.

We need not forget some other occasions of still larger natural catastrophes, although the loss of life was less than the instances just reported.

Apparently the most violent of recorded natural explosions occurred in 1815, when the volcano Tambora blew its top. This volcano is on the island of Soembawa, which is about two hundred miles east of Java and eight hundred miles north of Australia. Before the explosion Tambora was over 13,000 feet high; afterwards it was 9,300 feet high. When Tambora let go, it blew into the air about thirty-five cubic miles of rock and dust. Tambora at present shows an immense oval basin about four miles across, a type called by geologists a caldera. The name comes from an even larger and similarly caused craterlike basin named La Caldera, located on one of the Canary Islands. But apparently no one has recorded when that one blew its top.

Another of the largest and most recently discovered evidences of natural catastrophe is a meteorite crater reported in August 1950. It is located on the northern tip of Quebec, close to Hudson Strait, and is a completely circular crater, two miles across, with a high rim, and now filled with a lake. It is called Chubb Crater. It is in a country of granite bedrock, where volcanic origin is impossible. The evidence is that the crater was formed by an enormous meteorite striking the earth some time between 3,000 and 10,000 years ago, after the great glacial ice sheet was melted. When that meteorite landed, over a quarter of a cubic mile of solid granite—more than five billion tons—was blown out to form the crater and the rim.

The second class of catastrophes consists of those that are man-made, but unintentional. Mr. Green mentions a number of these in his paper. It may well be that United States statistics are fairly appropriate for evidence of this class.

The third class of catastrophes consists of those that are man-made and intentional.

It does not seem to me that any discussion of the catastrophic accident hazard can be complete without discussing man-made catastrophes of the intentional type: war, invasion, and genocide. Mr. Green refers to war and invasion, and mentions use of the hydrogen bomb, and suggests that such catastrophes will probably be handled by a moratorium on debts. But reliance on a moratorium on debts seems to me only a very minor part of the types of action which are open to actuaries and to life insurance companies.

The extent of some of these catastrophes may be indicated by the following figures:

1. Atomic fission bomb dropped by Americans on Hiroshima, Japan, on August 6, 1945, a city of some 340,000 population: killed and missing, 70,000.
2. Atomic fission bomb dropped by Americans on Nagasaki, Japan, on August 9, 1945: out of 250,000 population, 36,000 killed and missing.
3. Air raid by Americans on Tokyo, Japan, March 9, 1945, when 1,600 tons of conventional high explosive and incendiary bombs were dropped: 83,000 persons killed and missing. The wartime population of Tokyo at that time was about one and a half million people.
4. In World War I: about 8.5 million deaths among combatants.
5. In World War II: about 16 million deaths among combatants.
6. In Turkey, about 1919–1920: about one million Armenians slain in massacres.
7. Russia, in recent years: probably upwards of a million persons dead as a result of political liquidations.
8. Germany, about 1939–45: about 6 million Jews slain in concentration camps.

It seems to me that there are two additional things besides estimating rates of catastrophe hazard that life insurance companies and actuaries can do about all these three classes of catastrophes. One of them is study. The other is education towards prevention. Neither of these activities needs to be political in any way, which is the usual charge brought up against those who propose to take action in this area.

Casualty insurance companies carry out quite a considerable amount of activity in the field of study and of education on avoidable accidents of all kinds. For instance, the slogan which many of us have started to say automatically: "Drive safely. The life you save may be your own," is a result of education by casualty insurance companies. The Employers Mutual Liability Insurance Company of Wausau, Wisconsin, has, in fact, a safety engineering department with a vice-president in charge of it.

I would very much like to suggest at this time that a committee of the Society of Actuaries be appointed to study the statistics, the causes, and the prevention of catastrophic accidents, and report on actions that are open to actuaries and to life insurance companies.

In this way the hazards of catastrophic death, which worry so many of us these days, arising from hydrogen bombs, lithium bombs, the unlimited hatred expressed in genocide, and other extremely deadly catastrophes, might be somewhat reduced. The advantages to the people of the United States, to the life insurance companies whose interests we safeguard, and to our own families and ourselves, might be material.

In conclusion, I would like to quote two remarks, one that Mr. Reinhard A. Hohaus made in discussion at the Actuarial Society of America, in May, 1947, shortly after the Texas City disaster. He said:

> The companies have a responsibility not limited to paying the resulting claims. They have the further duty of analyzing what happened, and of trying to determine the lessons which they and other carriers, as well as policyholders and the public, should take to heart in the future conduct of their affairs.

The other is from a letter to me by Mr. F. W. Braun, Vice President and Chief Engineer of the Employers Mutual Liability Insurance Company. He said:

> For a long time we have wondered why the leading life insurance companies of America have not taken a greater interest in life conservation by having within their organizations a safety department, accident prevention department, or life conservation department. There is a need for life insurance companies, with their great research departments and their ability, to prepare this type of literature and get it to their life policyholders. It would pay big dividends.

R. W. WALKER:

Mr. Green's paper is certainly one of the most thought-provoking documents I have read in some time, carrying with it just enough mathematics for those, like myself, who are somewhat removed from facility with such things (if indeed we ever had it) and enough of the new concepts to make one sit up and take notice.

As to the mathematics I have no quarrel except perhaps to point out the order of magnitude of the items under discussion. The over-all termination rates of total deaths, accidental death and catastrophe are of the order of

$$q^{\text{Total}} = .01$$

$$q^{\text{Accident}} = .0006$$

$$q^{\text{Catastrophe}} = .0000075\,.$$

If, therefore, we assume the exposure of 10,000,000 lives, we are discussing mortality incidence of the order of 100,000 claims, 6,000 claims or 75 claims, respectively. Examining the standard deviation limits in these areas, *i.e.*, 3σ, the measures of which are about 945,231 and 26 respectively, we note and concede that the number of catastrophic deaths may vary widely. Even so, however, in terms of dollars the variation is small. Is it significant in the operation of a life company?

As to the remainder I probably should have no quarrel but it does seem to me it touches on some fundamentals that I, for one, hate to see disturbed.

It had always been my view and, I thought, the accepted view that contingencies were provided for through surplus accumulation. These catastrophic experiences have been felt in one area and the paper suggests a means of softening the blow in that area, *i.e.*, in the incidence of death claims. Catastrophic experiences might well strike elsewhere, such as at the investment portfolio. One might even suggest that the experience of the depression years was such a catastrophe. Contingency reserves are even now being set up for investment contingencies and we should expect that they would be usable for those contingencies. Other contingency reserves are set up for specific reasons, with surplus as a general pool. Is surplus and are these contingency reserves so sacrosanct that they cannot be touched when the contingencies for which they were set up do strike? Are they simply immobilized funds or are they available?

Perhaps a new era is at hand under which the contingencies can be reinsured. It does suggest, however, in the multiline operation of ordinary, group, industrial, etc., that perhaps surplus might be considered as interchangeable. We would in effect have one class of business insuring the other instead of one company insuring the other. The question is fundamental; the answer is certainly not at hand today.

(AUTHOR'S REVIEW OF DISCUSSION)

EDWARD A. GREEN:

Mr. Berkeley has given some interesting statistics as to the magnitude of some of the major catastrophes of history, both natural and man-made. He mentions the lack of information concerning the adjustments which were made in the premium calculation to take into account the narrowing of the definition of catastrophic accident, the inclusion of the deductible, the coinsurance, and the maximum features. In developing a gross premium acceptable to both parties, the practical aspects outweighed the theoretical, and broad adjustments were used without developing elaborate mathematical calculations to support the individual elements.

I am glad that Mr. Walker has underlined the fundamental problem which must be faced by every insurance company in considering the possibility that it may experience heavy losses from catastrophic accidents. I do not believe that there is any single answer as to whether it is best to rely upon the surplus as a cushion against all excess losses or to reinsure certain portions of the risk. It may be well to point out the different effect in a competitive market of a happening such as the depression of the 1930's which affected all companies more or less equally and a catastrophic accident which happens to occur in an area of concentration of a single company.