MATITUTE/FACULTY GENERAL INSURANCE STUDIES GROUP

REINSURANCE - CONTENTS

1.0	Objectives of the paper
2.0	Current practice in the reinsurance market
.1	Estrocessions
•2	The general nature of cover currently on offer
.3	Coinsurance
•4	Facultative covers and proportional treaties
•2	Non-proportional treaties
•6	Premiums for non-proportional reinsurance
•7	Hybrid covers
" 8	Claims settlement
.8.1	Proportional reinsurance and co-insurance
.8.2	Excess of Loss
.8.3	Catastrophe Excess of Loss and Stop Loss
•9	Claims fluctuation
3.0	Forecasting the development of the claims
.1	The effects of inflation
.2	Neasurgnent in real terms
.3	The exposed to risk
•4	Stability of development
•5	Stability in excess of loss
	•
4.0	Accounting and Reserving
.1	Accounting for outstanding liabilities
.2	The acounting year
.3 .4	Closing the accounts for the year Classification of risk for reserving
•4	Estimation of presiums for the year
•6	Estimation of cleims for the year
.7	Problems arising in practical experience
•8	Interest, inflation and currency conversion
•	
5.0	Claims Distributions
.1	Types of fitted curve
•2	Fitting curves to U.K. motor data
.2.1	Introduction.
.2.2	Conment on Table 1
.2.3	Comment on Table 2
.2.4	Goodness of fit and the effect of changing parameters
.2.5	Non-comprehensive cover
.2.6	The use of curves containing more than one component
•3	Fire Description films
.3.1 .3.2	Domestic fire Industrial and Commercial fire
•3•2	The selection of retention
•3•3	Problems with some Pareto curves
•3•4	Fitting curves to 1973 data
•3•5	Comments on Table 5
.3.7	Fitting curves to 1974 data
•3•8	Comments on Table 6
.3.9	Comparison of two insurers
.3.10	Comments on Table 7
.4	Consequential loss
	-

Catastrophe Lisks - provision by the direct writer 6.0 .1 Provision by reinsurance .2 Moydo Underwriters Catastrophe statistics for 1974/75 .3 .3.1 Aviation and Marine .3.2 Storm, Flood, Earthquake, etc. .3.3 Fire The basis for fixing minimum statutory solvency margins 7.0 .1 Ideal basis is impractical .2 The practical solution to long term solvency •3 The problems of supervision The solvency of a U.R. reinsurer .3.1 The cover held by a direct writer .3.2 Reinsurers situate abroad .3.3 Supervision by market forces has worked in the past •4 0.8 Bases for rating reinsurance .1 Facultative .2 Proportional by treaty .2.1 Control over profitability Excess of Loss working covers .3 Burning cost ratings .3.1 .3.2 Effects of inflation .3.3 Margins •4 Excess of Loss other than working covers Effects of inflation .4.1 The equitable sharing of costs in changing conditions 9.0 Delay correlated with size of claim .1 .2 Inequity casued by fixed retentions .3 of inflation An index clause to share the burden A specimen index clause .4 •5 Examples of the application of an index clause .6 Difficulties with index clauses External factors other than wage inflation .7 . . 8 Indexed annuities 10.0 Reinsurance Planning - Introduction .1 The reasons for reinsurance The variance of claims costs .2 .3 The practical reduction of variance .4 Independence of claims •2 The practical situation - excess of loss .6 The practical situation - stop loss .7 The practical situation - proportional reinsurance .8 Non-random variation Statutory and other limitations .9 .10 Percentage Loss, PML, EML. .11 Good risks and Bad risks The relation between classes and countries .12 .13 Reciprocity .14 Coinsurance .15 Marine and Aviation .16 Conclusion

APPENDIX

BIBLIOGRAPHY

REINSURANCE

SECTION 1 INTRODUCTION

1.0 OBJECTIVES OF THE PAPER

Two working parties were set up to report on actuarial aspects of reinsurance, and their members have each written one or more sections of this paper. These sections were then edited in order to provide a more logical development and to avoid too much repetition, so far as was practicable within the time available.

The aims of the paper are:-

- 1 To educate the profession generally and especially those students taking the new subject of general insurance, in the practical details of non-life reinsurance as it is currently conducted.
- 2 To review a number of technical problems that lend themselves to actuarial techniques and where present practice is sometimes based on commercial rather than sound statistical considerations.
- 3 To consider some problems other than those arising from stochastic fluctuations in numbers or amounts of claim.
- 4 To review the special problem of reserving and the treatment of IBNR claims, and to review the methods used in fixing premium bases and scales.
- 5 To consider the types of reinsurance cover needed by direct insurers or by reinsurers themselves (by way of retrocession) and means of testing whether the premiums and conditions asked give value for money.
- 6 The presentation of the underlying concepts to non-actuaries in terms that they can understand.

The paper does not pretend to be comprehensive although it is hoped that it will give the profession an insight into methods to be used to solve other problems also. It should be emphasised at the outset that reinsurance is international in character and that the bulk of reinsurance written in London is in relation to non-sterling countries.

SECTION 2 CURRENT PRACTICE

2.0 CURRENT PRACTICE IN THE REINSURANCE MARKET

The reason for reinsuring is primarily to reduce the risk of loss through abnormal stochastic variation, but with Lloyds Underwriters (who are limited by the committee of Lloyds in the total premium each may write) and some companies with small reserves or unbalanced portfolios the need for reinsurance operates through the need to preserve a sound (and in some cases a fixed and regulated) relationship between their retained premiums and their free reserves. Large companies whose shares are listed on a stock exchange often use reinsurance on a large scale in order to smooth variations from year to year in their experience, especially in those covers such as earthquake or flood where there is liable to be major variation from year to year. The aim is to present a smoother progression of underwriting results and profitability so as to help avoid unduly large fluctuations in share prices.

2.1 RETROCESSIONS

Retrocessions are reinsurances passed on by reinsurers. In some cases, such as unlimited covers, or where there is an accumulation of risk through several treaties with different insurers but based on the same physical risk, a reinsurer may well wish to limit his liability and will pass on by a proportional or non-proportional treaty a share of the business he has accepted.* These arrangements are worldwide and extremely complex. The variety of risks written is such that any part of the portfolio that is homogeneous is not sufficiently large to provide a good basis for tracing trends: On the other hand some degree of homogeneity must be found in order to trace any trends since these are needed in determining reserves.

2.2 THE GENERAL NATURE OF COVER CURPENTLY ON OFFER

Reinsurance may be either proportional or non-proportional. In the former a direct Insurer gives cover on the whole of a risk but agrees with a reinsurer that the latter will assume a stated proportion of the risk and receive the same proportion of the premium. Sometimes the proportion varies from nil to some agreed limit: this is a surplus treaty. If the proportion is the same for every risk accepted it is "quota share".

In non-proportional reinsurance the reinsurer pays that part only of each claim above a limit (excess of loss) or alternatively the whole excess of the total of all claims over an agreed portfolio limit (catastrophe/stop loss) It. is customary to fix a limit so that very few claims will concern the reinsurers. However, some small direct insurers fix a rather lower excess of loss limit so that a larger number of claims will exceed the limit; this is known as a "working cover". One advantage may be that the reinsurer will provide guidance in claim settlement and possibly in other ways.

2.3 CO-INSURANCE

Co-insurance arises where a number of direct insurers each take an agreed proportionate share of a risk. This is common for an individual risk covering a single large property or group of properties where a number, perhaps 50 or more, of insurance companies accept a part of the risk.

It also arises in Lloyds where each member of each syndicate takes a fixed share in all risks written by that syndicate and where each individual risk written by one syndicate may be only part of a total risk. It should be noted that there is a clear distinction both in law and in practice between proportional reinsurance and co-insurance, although the monetary effects are normally much the same. In the former case, the direct insurer is himself liable to the Insured for the entire loss but he has a right of recovery against the reinsurer.

In co-insurance there will be a "leading" (direct) insurer who will assess the risk and fix the premium basis and conditions but will assume responsibility only for a proportion of the risk; the "co-insurers" assume responsibility only for their agreed shares. It is only when a reinsurer or co-insurer becomes insolvent or fails to pay that there is any difference. In the former case, the direct writer bears any loss; in the latter case, the Insured bears any loss. If a direct writer fails then the normal winding up and insolvency rules apply.

Co-insurance will normally apply only facultatively (see 2.4) whilst much proportional reinsurance arises from surplus treaty or quota share arrangements.

2.4 FACULTATIVE COVERS AND PROPORTIONAL TREATTES

The simple division of reinsurance into proportional and non-proportional can be obscured in practice by the variety and complexity of actual arrangements, which are usually designed to reduce the vast amount of detailed work that would otherwise ensue.

The simplest case is the fire insurance of a large property. The direct Insurer will wish to retain the risk on only a proportion of the total sum insured and may make an individual arrangement to reinsure the rest of that one risk as a separate transaction; this is a <u>facultative</u> cover.

Usually, however, he will have one or more <u>treaties</u> that will enable him to reinsure automatically up to a fixed number of times his own retention. The amount actually retained is known as the direct insurers "line" and a treaty will allow him to reinsure, automatically, up to an agreed number of times the "line" subject to an agreed limit on the maximum amount of his retention. For example allo line treaty with a maximum retention of £250,000 will allow the direct insurer to place up to £2.5m on the treaty. There may be several treaties, usually used in sequence. For example if the direct insurer has a maximum retention of £50,000, a first surplus treaty may be for 10 lines and a second treaty for 8 lines. If that direct insurer takes a risk of £500,000 he can cover himself in a variety of ways including for example the following:-

Actual Retention	<u>lst Treaty</u>	2nd Treaty*			
50,000	450,000 (9 lines)	-			
50,000	300,000 (6 lines)	150,000 (3 lines)			
40,000	400,000 (10 lines)	$60,000 (1^{1}2 \text{ lines})$			
30,000	300,000 (10 lines)	170,000 (5% lines)			

* There will probably be some restriction on the use of the second treaty if the first is not fully used.

If the risk is £2,000,000 then this insurer can place at most £900,000 on his treaties leaving at least £1,050,000 cover to be arranged facultatively. In practice the sum insured, if it is large enough to merit reinsurance, often includes a number of separate buildings or a single building divided

in such a way that it is exceedingly unlikely that any individual claim will exceed a part (often only a small part) of the sum insured and the concepts of EML (Expected Maximum Loss) and PML (Probable or Possible Maximum Loss) have been introduced. A further complication is where several covers may be affected by a single event, for example a fire may give rise to claims under:

- (a) a fire policy on the buildings
- (b) a fire policy on the contents
- (c) a consequential loss cover for liability to employees and to third parties
- (d) a cover for loss of profits

The bases on which a direct insurer selects his retention and the way in

which cover is divided between one or more treaties and/or facultative arrangements are eften obscure and logically unsatisfactory. They are considered in Section 10. In general the reinsurer under a proportional treaty has only a very vague idea of the nature of the property he is covering. His control over profitability is explained in Section 8.

2.5. NON-PROPORTIONAL TREATIES

An excess of loss cover is suitable where there may be a few separate claims that could be very large in relation to the direct insurer's fund. A catastrophe excess of loss is where there can be a large number of "associated" claims, for example property damage following flood or windstorm. It covers all claims within one class arising from all events within a specified time span and this time span may begin at any time selected by the cedant after the losses have occurred. A stop loss cover is for the whole of a portfolio or class when the claims ratio exceeds a specified proportion of the premium earned. In the case of ordinary excess of loss there is normally no limit in the treaty to the number of claims that may qualify in respect of the period of cover, although there may on occasions be a limit to the total amount payable.

In the case of catastrophe excess of loss however the cover is often exhausted following a claim, but there may be a right to one or more reinstatements and if any or all reinstatements have been used up a further one or more reinstatements may be negotiated with reinsurers.

Motor and employer's liability insurance are commonly subject to excess of loss covers. It is normal to have two or three treaties, with varying layers giving continuous cover from the chosen excess point which we might call E. The reinsurers will be liable for the part of each claim that lies within their band, for example:-

Treaty	1	Limits E_0 to E_1
Treaty	2	Limits E ₁ to E ₂
Treaty	3	Over E ₂

Values for E₀, E₁, E₂ at present will probably lie in the range of £25,000 to £500,000 or even more depending on the situation of the ceding insurer and his view of the premium asked. Unlimited covers (over E₂) are not easy to obtain, but they are very important in the light of some recent individual damage awards as well as in view of the risk of the derailment of a train by a heavy vehicle or an accident to a bus with 70 or 80 passengers.

With current rates of inflation it is quite common to index the limits as explained in Section 9.

2.6 PREMIUMS FOR NON-PROPORTIONAL REINSURANCE

The basis for rating excess of loss or stop loss contracts commonly used is original gross premium income (OGPI) which is presumably regarded as the best available measure of the reinsurers risk: he will quote a percentage of this OGPI. This and the "burning cost" method are covered in Section 8.

2.7 HYBRID COTERS

We give an example of one hybrid cover that has been suggested, although we do not look upon this particular one with much enthusiaom. The basis was to be that a company which had at that time a maximum retention of £100,000 and two proportional treaties for 12 and 8 lines respectively, giving maximum cover of £2,100,000 should enter into an arrangement whereby it would retain a further proportionate amount up to £900,000 (that is £1,000,000 in all) on the basis that a new non-proportional treaty paid any individual excess of loss arising out of the whole of that part of the direct insurer's retention where the claim on that part exceeded £100,000.

For example, if the risk were £3,000,000 and these arrangements were fully used the direct insurer would retain in all £1,000,000 but place on the treaty 12 and 3 times his normal maximum retention of £100,000. In other words he would retain £1,000,000 and put £2,000,000 on the two treaties. In the case of a loss up to £300,000 the direct insurer would pay his one-third share. In the case of a loss (L) over that figure the loss would be shared as follows:

Direct Insurer	£100,000
lst Treaty	(12/30) x L
2nd Treaty	(8/30) x L

Special excess of loss treaty L/3 = 100,000

Records showed however that very little of the total claim cost arose from cases where L exceeded 10% of the sum insured so that the amount to be payable by the special excess of loss reinsurer was likely to be fairly small. It was however liable to vary substantially from year to year, so that he required a substantial fluctuation loading which appeared to make the arrangement potentially uneconomic. There is no limit to the types of arrangement that may be proposed but rate fixing can be very difficult.

2.8 CLAIMS SETTLEMENTS

The smooth working of the market requires a large measure of the utmost good faith, and the avoidance, so far as possible, of moral hazard. Current practice which we now outline seems to achieve a good balance between conflicting requirements, although by avoiding a lot of detailed work it sometimes operates unfairly. This may be an acceptable price to pay for administrative saving.

In many classes of non-life insurance claims are not reported until some time after the event leading to them has taken place. Long drawn out litigation over the determination of the ultimate liability for the accident or loss is one reason. Another is that it may be some years before the extent of disability can be fairly established and injuries thought likely to heal may sometimes get worse.

In liability insurance and especially in professional indemnity the delay often runs to several years and has been known to exceed 20. It should be noted that large claims, i.e. those subject to excess of loss reinsurance, are generally subject to much greater delay than normal claims. As will be seen later this effect compounds with effects of inflation to make it excessively difficult to forecast the probable level of excess of loss claims. We shall shortly consider the problems of Incurred But Not Reported (IBNR) claims including developments on reported claims.

2.8.1 PROPORTIONAL REINGURANCE AND CO-INSUMPLICE

A claim will normally be investigated and settled by the direct or leading writer as the case may be. There will be some restraint on the direct writer to make an economical settlement, although if he retains only a small part, say 5% of 10% of the risk, there could be a temptation in an individual case to generosity. However any substantial generosity would be reflected in adverse results on the treaty and by lowered return commission or a refusal to renew. Settlement under facultative cover is on an individual basis. On treatics it is normally done periodically, probably quarterly, on a bulk basis without supplying details of individual losses.

2.8.2 EXCESS OF LOSS

There will normally be very few claims and their treatment will often be agreed with, or even taken over by, the reinsurer. Settlement is on an individual basis and may be in one or more instalments where there are several payments made after the excess limit has been exceeded. Reinsurers commonly ask to be notified of claims likely to exceed a figure of about $\frac{3}{4}$ of the retention because of the effects of inflation and other changes explained in Section 9.

2.8.3 CATASTROPHE EXCESS OF LOSS AND STOP LOSS

The reinsurer will be almost totally dependent on the good faith of the direct writer, and on the face of it there is a serious moral hazard. For example, a widespread storm may be so severe as to make it clear at once that there will be a claim under a catastrophe cover. It then follows that if the direct writer settles generously his generosity will be wholly at the expense of the reinsurer. All the latter can do is to examine claims from other insurers and form an idea as to whether the claim on him is prima facie reasonable; he can protect himself by putting up his rates sharply or even, if he thinks fit, declining to renew. Property claims are probably one of the few areas outside life assurance where stop loss covers are reasonably practicable. Similar remarks apply to stop loss.

2.9 CLAIMS FLUCTUATIONS

The sources of fluctuation in claim costs, other than random variation in the frequency or severity of accidents, are set out below together with approximate rates of increase from one year to the next.

(a) Monetary inflation and changes in currency value (in the case of non-sterling business:

Years	1925	-	1973	-5%	to	+10%
	1974	-	1975	15%	to	30%

(b) Changes in the basis of awards by the Courts tend to go in jumps every few years but do not average more than (per year) ½% - 2%, although there are major exceptions especially in the United States of America.

- (c) Legislative changes, sometimes retrospectively, in the basis of compensation. At a guess from -50% (e.g. when compensation for noneconomic loss is disallowed) to +50% (e.g. on introduction of no fault legislation).
- (d) Changes in administrative costs, and in legal and technical service charges. These changes are relatively trivial, and any savings may be more than cancelled by requirements for more detailed statistics and by administrative controls; the range is perhaps -1% to +1%.
- (e) Changes in claim frequency or severity as a result of technological or social change. For example new industrial processes, major changes in the size of ships and aircraft, safety measures, lower use or poorer maintenance of the roads arising from economic stringency. In UK motor insurance the change per year over a decade is probably of the order of O to -2%. For other classes of business the range could be greater and could be either positive or negative.
- (f) Changes in interest, rates and in investment conditions, at least -40% to +30%, when and control to an Converting of the the alexand in the States of the option

It must be remembered, in assessing the changes above that they are all cumulative changes and can give rise to quite large changes over several years. Some of the more gradual changes present no serious problems but the major changes which have taken place under groups (c) and (b) and more recently (a) and (f) can have a quite devastating effect on claims under excess of loss and stop loss policies. The magnitude is so great as to lead to serious questions as to the equitable sharing of these risks between the direct insurer and the reinsurer. This is an area where the market is groping and where it is very difficult to find a basis fair to both parties. We discuss this in Section 9.

SECTION 3 MEASURING THE LOSS

3.0 FORECASTING THE DEVELOPMENT OF THE CLAIMS

In times of greater monetary stability non-proportional reinsurance rating could well be based on curve fitting and trends of the frequency and incidence of large claims within each class of business, or some narrower groups, and of large accumulations of claims associated with some natural phenomenon. Much theoretical work has been reported in the ASTIN Bulletin and many other references will be found in the bibliography. The practical aspects are explained in Section 4.

Most liability classes give rise to an occasional very large claim that could be classed as a catastrophe. The frequency of such events is so small within any given class that it seems most unlikely that they can be regarded satisfactorily as either belonging or not belonging to some particular claim distribution. We shall refer to this in Section 6, in relation to the explosion at Flixborough.

3.1 THE EFFECTS OF INFLATION

When we move from theory to practice we have to take into account the changing value of money. If claims are based, as they frequently are in liability insurance, on earnings levels at the time of "payment", it would clearly be stupid to add all the pounds, dollars and deutschmarks together as though they were the same units of currency. They are not, and it must be clearly recognised that it is just as foolish to add 1976 £'s to 1970 £'s as it would be to add 1973 £'s to 1973 \$'s. We shall now consider how we might obtain a more satisfactory measure of risk ignoring the effects of inflation, but first we shall see how to convert it to a cost in f's or \$'s or any other currency, after making specific assumptions about future inflation and currency rates. In doing so we shall for the present ignore interest earnings and capital growth or loss on investments held (or to put it in another way we shall not discount future payments).

3.2 MEASUREMENT IN REAL TERMS

The most satisfactory way of achieving our object is to express the cost of payments under claims for incidents which took place at a given time in terms of the money of that time. For example claims notified or occurring in 1974 should be expressed in 1974 £'s and payments made in later years should be deflated accordingly back to 1974.

There are two practical difficulties to be considered. One is that we do not have an immediately available price or other index to convert a claim payment made at time t to the equivalent of one made at time o.

The other is that the time at which such an index should be taken may be anywhere between the date of accident and the date of payment. In some cases (e.g. when average applies) it could even be earlier than the date of accident. Since most excess of loss reinsurance will be concerned with liability for bodily injury, or other matters related to wages or loss of earnings, it is appropriate to use an earnings index and to base calculations on the date of payment of claim, which will normally be close to the date when quantum was agreed. For forecasting purposes it is much more important to be consistent than to be exactly right.

If we consistently convert by a wage or earnings index rather than by a retail price index and use date of payment of claim rather than date of accident or agreement or reinstatement, it is likely to make little difference to the result. If, however, conditions are so variable that large differences arise then the major uncertainty of future inflation rates or changes in the law on compensation would far outweigh inaccuracies from using the wrong index or the wrong "relevant" date.

3.3 THE EXPOSED TO RISK COHORT

The other question is the size of the cohort to take in examining past experience. Since most reinsurance is on an annual basis it would seem wise to use the cohort of all claims for which the accident occurred during a particular reinsurance year and to assume that all cover and all accidents are concentrated at the middle of that cohort year. It will be only in the case of a very rapidly changing portfolio that this will introduce distortion of any importance.

We do not here consider whether a "year" is a calendar year (or an accounting year) or the policy years beginning in any calendar year or accounting year, since this does not affect the principle. There is however often a practical advantage in using the calendar or accounting year whenever there is a common external source of risk, for example weather.

We can then "deflate" all payments by the ratio of the index at the middle of the cohort year to the index at each individual date of claim payment. Alternatively we can deflate all payments in each successive year by the ratio of the initial index to that at the mid point of the appropriate payment year. Put in algebraic terms this is

$$C_{O} = \sum_{\substack{i=0}}^{\infty} P_{t} \times \frac{I_{o}}{I_{t}} = I_{o} \sum_{i=1}^{\infty} R_{t}$$

Where C is the "original" cost, that is what the claim is assumed to be in

where to the Be taken as either a continuous or discrete integer variable measured from the middle of the colority ear and P is the payment at time t and I is the earnings index at time t. Rt is the proportion of C, which develops in year t, and the summation is over years (we could use other discrete time periods, such as quarter years in this case).

3.4 STEDILITY OF DEVELOPMENT

If we find for each band of t and to a sufficient degree of approximation that ($P_{t} \ge 1$) is summed over the band which spans a reasonably long period of time such as 3 months or 1 year, is a constant proportion of C from one cohort year to another (that is the payment in yeal terms is reasonably stable between cohorts as it seems to be in motor insurance). then we can estimate the cash sum of undiscounted chaims for a given cohort year which has not been fully developed as being

$$C \neq C_{o} \left(\sum_{i=0}^{\infty} Q_{t} \right) / T_{o}$$

 $t \neq 0$

Where C is the expected claim amount based on the previous year's average claim amount multiplied by the number of claims in the current year, or is based on payments to date where there has been at least one year's development, and where $Q_{\rm c}$ is the ratio of R_t to $\bar{R}_{\rm c}$ that is the real proportion paid in year t, and where some or all of the I_t are estimates of the future level of the earnings index and where the cohort year may be next year, this year or some earlier year not yet fully developed.

Alternatively, this formula can be used in reverse to estimate values of J which are similar to I but amalgamate the inflation inherent in I with other trends in claim size. Such a technique has been used by Greg Taylor for UK Motor Insurance (see bibliography) where the proportion of real costs paid in any one calendar year of development scems to be fairly constant from one cohort year to another. This may be a dangerous assumption for other classes of insurance. Taylor's method used the payment "triangle" to estimate both Ω_{t} and J instead of assuming that a given earnings index I could be used as a substitute for J and any remaining irregularities could be superimposed on Ω_{t} .

In the case of fairly stable data in direct insurance Taylor's method would have the advantage of revealing differences between J_t and a suitable readily available index I_t caused by serious external influences beyond monetary inflation (e.g. change of laws or in the level of court awards). Whether in fact this is possible depends on stability in the rate of claims outgo in real terms and also on whether the equations leading to Q_t and J_t are well conditioned. We know that there are disturbances to the rate of payment in real terms caused by influences over which we have little or no control and it seems obvious that the equations may well be quite ill conditioned in the sense that large changes in R_t with compensatory large changes in J_t may give a fit little worse than the best fit, simply because the peaks of such fits tend to be rather flat. There is clearly scope for research here. The effect of changing parameters is illustrated in Section 5.2.4.

3.5 STABILITY IN EXCESS OF LOSS

When we come to excess of loss covers however there seems little doubt the Greg Taylor plan to separate out Q_{\pm} and J_{\pm} will be unreliable simply because of large random fluctuations in the incidence of claims and of payments. It would be much better to use an external index I in order to derive more stable values of R_{\pm} by controlled elimination of the superimposed irregularities. Unless one is dealing with working covers, an individual excess of loss treaty should produce very few claims. More than 10 or 20 a year (irrespective of the size of the original portfolio) indicates an abnormally low excess point. It seems therefore that the method of reducing all payments to real terms might be suitable to give some idea of the distribution of the 5 or 10 largest excess of loss claims. This was the procedure word by Johnson and

Hey*and it demonstrated how long is necessary before a reliable estimate of claims is available for any given cohort year and how large the variation from one cohort year to another appears to be, at least in very broad terms.

The reduction of the problem into its component parts by separating the effects of inflation from those of random variation is an essential first step in the process of estimating reliability of forecasts. Such a measure of reliability is a vital factor in assessing the desirable level of solvency margin. This is discussed in Section 7.

SECTION 4 ACCOUNTING AND RESERVING

4.0 INTRODUCTION

This section was drafted by a consultant who has mainly been concerned with Lloyds Underwriters but the principles will apply widely with suitable modification to the detail.

4.1 ACCOUNTING FOR OUTSTANDING LIABILITIES

In all reinsurance business, especially excess of loss and liability, outstanding claims are often much dolayed before they are passed to the reinsurer. Outstanding claim notifications are notoriously unreliable because they pass through too many hands without any standardisation of records (although matters are improving in this regard). Where wide divergencies of opinion occur (e.g. the extraordinary difference one sees between the client's figure and the attorney's figure in USA cases) it is impossible for the reinsurer, perhaps four times removed from the scene, to judge the position properly. Often claims are notified without any amount at all being stated. Large liability claims are notorious for the delay in their settlement by the direct insurer (see 2.8). Lloyd's still has a few claims open from before the last war. One Australian insurer still has a 1924 workman's compensation claim outstanding, and many others arising before 1940.

Individual risks placed with Lloyd's, whether direct or reinsurance, often involve large amounts at risk. Hence syndicates protect themselves by elaborate systems of reinsurance outwards. Individual risks are reinsured facultatively, excess of loss reinsurances are usually arranged on sections of the total portfolio net of the facultative reinsurance, and finally stop loss may be arranged on the resultant net portfolio. All this reinsurance is placed in the same market and tends to circle around. A syndicate may easily be involved at arm's length twice removed in a reinsurance which it has itself placed. The accounting can go on reflecting the ripples for several years.

Both these reasons explain the impossibility of producing accounts both speedily and accurately. Much confusion about reinsurance accounting springs from an inability to recognise that the methods used are designed to meet conflicting and incompatible objectives. The fundamental conflict is between speed and accuracy. If you want the results quickly they will be wrong, whilst it is possible, but not inevitable, for the results to be exact if you wait long enough. For reinsurers long enough is commonly ten years and could easily be thirty or in some cases fifty. If we are saddled with payment by indexed annuities even longer periods could arise unless sensible arrangements are adopted to keep the flat annuity separate from the general fund and the indexed part in some compulsory pool.

It is therefore necessary to strike a balance. It is also necessary to realise that for a reinsurer with a catastrophe account the result for a

period of just one year may be a very misleading guide to the real return likely to be received on the assets involved over a longer period and some form of spreading is highly desirable. This is covered in Section 6.

4.2 THE ACCOUNTING YEAR

A reinsurer writes business for a year (it is convenient if we do not concentrate on the first year of this business) and at the end of that year he is required to produce accounts and analyses for the purposes of:

- solvency, for the State or other supervisory authority (as explained in Section 7)
- 2. taxation, for the Inspector of Taxes
- 3. profitability, for the shareholders and The Stock Exchange or for members of the syndicate
- 4. premium rating, for the underwriters.

He has a choice as to whether his accounts are in respect of the "business written" in a year or the "losses occurring" in a year.

If the basis is "losses occurring" in the year, claims are allocated to that year according to the date of the accident. The accounts are based on the cover given in the year and the accounting in regard to the contract is relatively simple, but provision (in addition to an unearned premium reserve) should be made for losses in respect of cover still to be given for which a premium has been received but where it is likely to be inadequate for the unexpired risk. Excess of loss reinsurance is usually accounted for on this basis. But if the underwriting and accounting years coincide there will be no need for any unearned premium reserve. Most proportional treaties are accounted for on the "business written"

during the year. Claims are allocated to the relevant year according to the date on which the premium was due to be paid. For example a proportional treaty is written for twelve months from 1 January 1976. It reinsures all risks (after lay off of excess of loss and surplus lines) attaching within that period. These "attaching" risks begin on some day during 1976 and usually run for twelve months. They may however run for one week, one month or exceptionally two or even three years. If such a risk attaches on 1 August 1976 and runs for fifteen months, it means that claims arising between 1 August 76 and 31 October 77 are covered by the treaty applying to the underwriting year 1976.

There are considerable practical difficulties in making sure that these allocations are correctly made, since in the main, one is dependent on human intervention and coding, rather than automatic procedures.

In this case, as in the case of most direct business, there will be premiums still to be earned at the end of the "Treaty" year (31 December 76) and the claims in respect of the uncarned premiums in addition to outstanding and IBNR claims at the year end to be paid. These are known as portfolio premiums and portfolio claims and will be considered in more detail in the next Section.

4.3 CLOSING THE ACCOUNTS FOR THE YEAR

It is customary for accounts in respect of "business written" in a year to be kept open for three years, at the end of which a balance is struck. Accounts for "losses occurring" in a year are customarily closed as at the end of that year and a balance is then struck and is not, at least in published figures, subsequently adjusted.

Accounts are required fairly promptly where it is necessary to give information to shareholders (although insurance quarterly returns of premiums (with or without a premium reserve) less claims paid are an absurd following of an irrelevant convention). These accounts are required to declare dividends or, perhaps more importantly, to adjust the position between incoming and outgoing members of a syndicate. Very often, at least in the case of non-marine- business at the end of twelve months, a "portfolio premium" is transferred out of the account into the account of the next underwriting year. It may be based on an unearned premium reserve alone (on a pro-rata basis) but way also include an unexpired risk reserve. It is not obvious whether someone on a treaty for a year should have the profit, or hear the loss, arising from the cover given in that period (no unexpired risk reserve) or the business written during it. The decision in favour of one or the other should be a matter of negotiation (which includes acceptance of standard market practice), but it is important that the accounting reflects the agreement.

At the end of the year or more commonly at the end of the following year, "portfolic claims" are similarly transferred. These are an estimate of the claims outstanding at that time in respect of incidents which arose in the underwriting year.

These portfolio premiums and portfolio claims can be quite large and are not easy to estimate, though over a period errors will tend to cancel out.

With one year accounts few, if any, of the large excess of loss claims will have been notified, let alone settled. This procedure leads to a more rapid accounting but it involves somewhat rough justice between underwriters who come on or off the treaty. However, most underwriters tend to remain on a treaty from year to year, although they may vary somewhat the percentages they write.

The Lloyd's "reinsurance to close" at the end of three years is a much more important figure than in the case of a conventional company as it settles a final distribution of profits. These three year accounts set the main emphasis on reserves for claims outstanding, IBNR claims, and for contingencies. The accounts are closed at that time in order to determine the profit or loss and to report it in the published accounts. They are normally closed by reinsurance into the next year's "account"; this procedure continues cumulatively. For example, if an "account" opens on 1 January 1970 then:-

at 31/12/72 it is reinsured into the 1971 "account"

at 31/12/73 the 1971 "account" including the run off of the 1970 is reinsured into the 1972 "account"

and so on.

Although these accounts are regarded as closed at the end of 3 years, each "account" should be and often is kept separate within the underwriter's books so that its run off is traced indefinitely for statistical purposes even though it is technically closed in the books of account. In exceptional cases an account may be closed by external reinsurance rather than to the next year's account of that particular underwriter.

During the three years, the position to date is not ignored. It is general policy to let the account run if it appears to be profitable but to take steps to "strengthen" it if results look as if they will be poor. At the very least management would take a critical look at the strength of a Company in regard to its overall free estate, and in many cases extra technical reserves would actually be set up. This is not so easy for a Lloyd's syndicate as "names" are not usually involved until the three year point is reached. However, the Lloyd's audit reserve percentages must be met at the end of the first and second year. For a reinsurance account it is virtually impossible to tell the trend at the end of the first year and even at the end of the second year, the picture is not much clearer. Hence it is usually impracticable to have a close examination before the end of the third year.

4.4 CLASSIFICATION OF RISK FOR ESTABLISHING RESERVES

In order to trace trends and obtain ratios to be applied in determining reserves it is essential that the risks be classified into reasonably homogeneous groups. The most important sub-division is that between long tail business (e.g. liability business) and short tail business (e.g. physical damage). Much of proportional reinsurance is short tail business for which information is available sooner than with liability cover. However, in these cases the reinsurer will usually have very little information of value from his cedants as to premions and claims. Advices will continue to be received for some years leading to "movements" of both premiums and claims in the account.

There is always difficulty in obtaining reliable information on claims outstanding when the reinsurance company is four or more times removed from the original source, and changes in office practice anywhere along the pipeline will affect end figures. These changes may be either in coding the figures or in the inherent delays in processing them. In liability claims the original insurer may be able to make a fair judgement of the likely outcome of the litigation between claimant and cedant, the reinsurer frequently cannot. The broker, who is the intermediary in the pipeline, often regards notification of figures of claims outstanding as little more than a nuisance. At best, there are often very real difficulties in tracing outstanding loss figures for example on an excess of loss treaty written to cover a whole portfolio of business.

It is almost standard policy for underwriters to write "lines" which can involve very high claims and then to protect themselves through retrocession. Where retrocessions are proportional, either on individual risks or on classes, it is possible to work on net figures. However, retrocessions may be either:-

- 1. on part of a risk e.g. total loss only for Marine or,
- on an excess of loss basis whereas the original risk is on a proportionate basis or,
- 3. on a catastrophe or "burning cost" stop loss on a whole account.

These all result in distortion when net figures are being built up, or else in an inability to split up the whole account retrocession to show its effects on part of the portfolio. For the few very large claims some clerical adjustment must be made. Although it would appear wisest to sub-divide the business until each separate group is homogeneous, this cannot be done in practice because it will give results which are altogether too"rough" to afford any true indication of trends in claim ratios.

4.5 ESTIMATION OF PREMIUMS FOR THE YEAR

Proportionate treaties of reinsurance are for one year and are almost invariably written on the basis of quarterly returns. In practice very little premium income is returned within the first two quarters. It straggles in over a period of some 2½ years with minor amendments still continuing thereafter, sometimes for several years. Excess of loss and stop loss treaties are written on the basis of a percentage of the office gross premium income for the year concerned. The deposit is based on a fairly close approximation to expectations but the adjusting premium is not received until about three months after the close of the period. In practice the premium income figures on which loss ratios are calculated consist of simply a build up of booked premiums (including the total premium booked even when paid by instalments). Premium items which come in mainly during the first few years but as a slow and steady dribble thereafter include the following items:

- 1 Portfolio premiums transferred from earlier years.
- 2 Adjustments calculated at the end of the period of insurance, due to mid-term alterations, declarations of risk by the insured etc, which all affect the direct writers OGPI.
- 3 Profit Commission (usually negative to underwriters).
- 4 Interest on reserves.

5 Periodic advices on contributing "treaties". (But before transfer to reserves).

On two actual examples the following figures were obtained as a percentage of premiums booked.

Year of Development	1	2	<u>3</u>	4	5	<u>6</u>	.7	8	9
Short-tail premium income about £3.5m per annum %	67	27	5	2	1	1. ₂	0.1	0.1	0.1
Long-tail premium income about £0.8m per annum %	60	30	9	4	2	1	1 <u>2</u>	14	1 ₄

On pro-rata treaties the fluctuations are even further extended, usually only about 40% of the premium income being reported within the first 12 months. Whilst it may be essential for accounting purposes to keep records open for several years, there is little value statistically in bothering about the last 1% of the premium.

For these purposes premiums include premium reserves or portfolio premiums derived from earlier closed years.

*That is premiums in respect of business "put on the books", or, in other words, where the underwriter has gone on risk.

4.6 ESTIMATION OF CLAIMS FOR THE YEAR

The flow of claim payments out of the reinsurance account is delayed to a larger degree than might be expected. Typical spreads are:

	Percentage of total claims paid in year and outstanding at year end					
	<u>Year 1</u>	Year 2	<u>Year 3</u>	• • •	Year 8	• • •
<u>Long-tail</u>						
emerging claims paid in year	8	20	20	• • •	4	
remaining claims outstanding at year end	92	72	52	•••	20	• • •
Short-tail						
emerging claims paid in year	20	50	20	• • •	1	
remaining claims outstanding at year end	80	30	10	• • •	1	• • •

This delay enlarges the effect on profitability of reserving for inflation and discounting for interest income. In the case of a reinsurance company it is seldom possible to separate out true incurred but not reported (IBNR) claims as such from changes in amounts of claims already notified as outstanding which arise from the updating of advices or from final settlements; this is partly because, in many cases, the result barely justifies the effort. There are at least five different methods of making the actual accounting entries for claims paid, outstanding, and IBNR. Method 1 is the basis of the Lloyd's audit requirements. It specifies, when closing the account, the minimum technical reserves required and relates them to the earned premiums.

Lloyd's Audit	Minimum	Reserve	Requirements	As	at	31/12/75
	، الله بد الأربية الأربية الأربية الأربية الأربية المالية الأربية المالية الأربية المالية الأربية ال	an de sinde stage et de stage setter andere des				وجواهم سمودية وبالمجوي ويتؤاذ فتعرآ ومطالبة فالهوان

(all	figures	are	percen	tages)
------	---------	-----	--------	--------

3 Year Accounts	"open"a	open"accounts "closed" accour			.ccounts	nts		
Year of Development	1	2	3	4	5	6	7	8
Non-Marine Excl Motor:								
Short Tail	57¹₂	20	5	2	1 ₂	ł	-	
All Others	85	65	45	35	25	15	10	8
Motor: UK & Ireland	65	20	10	4	1	-	-	
All Others	82 ¹ 2	50	22 ¹ 2	15	7 ¹ 2	5	3	
Aviation: Short Tail	45	15	7¹ <u>;</u>		-	01	-	
All Others	65	45	30	11	5	2 ¹ 2	1	
Marine:		1						
Time Liability	77½ 95	47½ 85	32¹₅	20	12 ¹ 2	7¹ź	5	25
Voyage	55	20	75	3 ¹ 5	15	-	-	
War	25	5	2 ¹ 2	-	-	-	-	***
The minimum rese	erve (for	claims	l outstar	nding ar	nd IBNR)	is for	md	

by applying the above percentages to premiums booked to date.

Method 1 suffers from the disadvantage that it takes no account of results to date from the underwriting point of view. However, it should be noted that there are two caveats to the straight application of the percentages in the above table. Firstly, the actual percentages used are varied each year in the light of how the year appears to be developing for the class concerned. Thus Lloyd's committee applies a correcting factor to all syndicates on an equal basis. Secondly, syndicates are instructed to have regard to any higher reserve requirements that may be shown to be necessary by the application of one of the methods 3,4 or 5. Newever, no advice is given as to how these methods are to provide for IBNR. Method 1 seems to be the best approach in the first year or two of the development of the account, when the claim have only started to arise.

The following table is a summary of the various approaches possible:

	Method	A claims paid	B claims outstanding	expressed as a % of	C IBNR claims	expressed as a % of
1	Lloyd's audit	actual	Historical basis	premiums to date	historical estimate	premiums to date
2	"cohort" or direct writers	58	**	claims paid to date	**	claims paid to date
3		98	Individual estimates or notifications		**	premiums to date
4		87	**		11	claims <u>p</u> aid to date
5	Recommended after 2 years	Ħ	n		11	claims paid plus outstandings

Much detailed analysis has been carried out in recent years into Method 2, the Cohort method, which has been described in Section 3 of this paper. This method appears to work well for a large portfolio of relatively small risks (Motor or Householder's comprehensive) but it is of much more doubtful validity in the case of a large reinsurance company which may suffer heavy individual claims, including catastrophes, but may be protected to a greater or lesser extent by reinsurance treaties. This method is explained in detail by Foster, in the booklet on IBNR (see bibliography).

There is little to choose between methods 3, 4 and 5. No evidence has been produced so far as to which of these three methods is "best" or even how good they are, but statistical evidence may be obtained in future. On theoretical grounds Method 5 is recommended. However, that method is useful

^{*} For a class such as direct UK Motor the "relevant" period for IBNR is (more or less) the last two months of the accounting year; unfortunately this is the period about which little is known. For liability or professional indemnity reinsurance we may need up to 10 or more years experience, and some assurance that conditions have not changed radically.

only when the claims outstanding figures have begun to settle down, which normally does not occur until at least the third year of development of the account. Figures should be established from past experience using each of Methods 1 and 5 and basing the percentages on the average of a few underwriting years in each case. If possible the account should be Sub-divided in at least the following three ways.

- 1. Short as against long-tail
- 2. Main types of business
- 3. Main classes of reinsurance.

Reserves should be calculated by both methods, and the higher figure used, each year of development being taken separatoly. Finally instanjudgement should be brought into play since it is have that almost nothing can replace experience and the second sight which some Underwriters and Claims Personnel and perhaps even some Actuaries and Accountants seem to have in this field. The over optimistic desire to transact more business should however be avoided! Judgement should be used only to increase the reserves not to reduce them.

There are two particular circumstances that require further reserves. Firstly, if the reinsurance inwards is of the stop loss type, or if it is an excess of loss cover depending on burning costs, there is a special danger of claims escalating more than expected. The London market is working in a comparatively blindfold manner in such circumstances, but its incestuous nature is some protection in this regard, provided the premium is always high enough to prevent selection operating against the market , since the effect is to spread losses rather more uniformly.

Secondly, most catastrophe risks are of a nature that produce particularly heavy claims once in say ten years or fifteen years or perhaps twenty years. It would seem wise to build up, year by year, a special reserve fund, but difficulties exist in that special extra provision of this nature may well not qualify for tax relief. Reinsurance outwards as an alternative to the special reserve fund is not a complete answer to the problem. It is difficult to obtain reinsurance sufficiently large to gover the effects of a catastrophe of considerable dimensions, and since other Underwriters will be in the same position, also looking for reinsurance, the resultant effect is liable to spread the losses throughout the market so that they bear heavily on virtually every Underwriter.

4.7 PROBLEMS ARISING IN PRACTICAL EXPERIENCE

Lloyd's method gives full rein to underwriters view of the account but it appears nevertheless to be rather hit and miss as far as IENR factors are. concerned for the more ordinary group of business. For 1973 the Lloyd's audit percentages appear to have been considerably too low for many syndicates. That year was not such a good year as were the years 1970/72 - particularly so in the case of pro rata treaties. 1973 appears to have been a classical example of a year when reserves, which expressed as a percentage of premium income, were too low because the premiums themselves were insufficient.

Year of Development	3	4	5	6	7	8	9
Pro-rata Treaties			argania utori to - 18, ranganati				4.00×10000000000000000000000000000000000
Non-Marine "Short-Tail"	1.0	2 ¹ .	12		-	-	
Non-Marine "all other")	48			2	1	***	-
Marine/Aviation - all)							
Excess of Loss including I	ondon	Marke	t Exce	ss of I	loss		
"Short-Tail"	5	3	2	1	-		-
"All Other"	10	6	4	3	2	1.	
except for one experience							
of Non-Marine "all other"	63	35	22	14	8	4	2
Facultative and Direct							
"Short-Tail"	1.6	6	1		-		-
"All Other"	45	24	10	5	2	1	

An example of the application of method 5 is given in the following table

The pro-rata treaties of the experience shown in the table were quite heavily related directly to the London Market. This results in an upward surge in loss ratios at about the third quarter of the fourth year of development, due to the reinsurers "closing out" their third year accounts by setting up additional reserves. The figures are agreed on in April or May and take a few more months to work their way through the market to the reinsurer. This feature necessitates extra IBNR reserves at the 3-year point but by the fourth year they appear as an additional outstanding claim figure. The Non-Marine treaties are, however, an exception to the rule, as they are usually written on a "losses attaching" basis and closed at the end of every year by means of portfolio premiums and loss reserves. Hence they settle down more rapidly but not necessary accurately. It will be noted that there is no effective difference, as far as pro-rata Marine treaties are concerned, between Short-tail and Long-tail. If the premiums are split between these two in proportion then the claims must be split in the same proportions.

In general Short tail business does not present much of a problem since all reserves including IBNR are relatively small by the end of the third year. Long-tail business is much more of a problem. "All other" given in the above experience is really a mixture of Short and Long, much of the Long not being particularly Long. Non-Marine excess of loss is clearly longer than the other types of Long-tail. There was no discernible difference between excess of loss for facultative business in Marine or Aviation. Only in Non-Marine was the difference discernible.

Although the ratios shown in the table were reasonably steady (bearing in mind the extreme roughness of the data) they actually related to loss ratios differing quite markedly from one underwriting year to another. This factor would seem to indicate the suitability of the approach. It should be noted however that if the percentage is P and the amount paid to date is C, claim payments and outstandings are:

$$\frac{C.100}{P}$$
 and the outstandings therefore are
C.100 - C = C(100-P)

Р

Р

If P is more than say 80, a small change in the proportion actually paid will make only a roughly proportionate change in the estimated outstandings, but if P is around 50 a small change in payments will give rise to a change in the estimate required of about double, and for smaller values P (that is reserve figures much over 50) the change is greater still.

The actual percentage paid is sensitive to changes in rates of payment and inflation and for reinsurers to the speed of reporting.

If an account is showing a high loss ratio by, say, the end of the third year of development, its IBNR can be expected to be high in proportion at that point of time. Provision has not been made in the above table for the extra dangers of sudden surges in claims notified at a later stage in the case of excess of loss and stop loss business. Some extra implicit reserve is advisable in these cases. Although similar percentages were derived for years one and two they were found to be less reliable (except for direct motor) for this reason they have been omitted from the table. Method 1 should be used for these years.

Failure to distinguish properly between Short tail and Long tail business can be caused by the use of the current Department of Trade class grouping, at least without further sub-division. A proper statistical analysis will be aided by the use of the EEC classifications or by the requirements for the revised DOT returns currently being drafted, which are due to be adopted in the United Kingdom within a few years, and which require that each of Marine, Aviation and Motor be separated between physical damage and liability. If we consider for example a large Aviation fleet risk, including hull and several types of liability and covering a number of aircraft for a period of one year for a combined premium we find that each underwriter makes his own decision as to the correct split of the premium between hull and liability. Indeed some underwriters request that the premium be not split at all, while others "60% - 40%" or "50% - 50%". The reserves that are carried when the account is closed will be affected accordingly when they are based on premiums. If the claims are simply analysed according to the risk analysis both the Short tail and the Long tail results will be the same. Hence there will be no method of testing statistically whether the allocation between Short tail and Long tail was correct. Nevertheless most of the market does adopt this method and there is generally no request for the claims to be allocated, at any rate the smaller claims. Large claims are advised with full information. Proper reporting is required by Lloyds in respect of Marine, but not in respect of Aviation or Motor. Most companies are believed not to require it at all.

4.8 INTEREST, INFLATION AND CURRENCY CONVERSION

If an insurer, and particularly a reinsurer, carries on a class of business where the average delay in settling claims is n years, he will have something like 0.7n to 1.3n times his gross annual premium in his technical reserves plus solvency margin, depending on the spread of business. These should be showing an overall return (income plus capital gains less capital losses) autributable solely to his carrying on that class of insurance business. After making some payment to the holders of the risk capital representing a fair return on their money (including compensation for taking the risk of losing their capital should losses arise), the balance of the income is and ought to be accounted for as a receipt from that class of business.^b Whilst it is customary not to show this income in the class accounts, it is normal to take credit for it in an oblique way by accepting a situation of no underwriting profit, or in some cases quite substantial underwriting losses, which would be more than offset by the interest income. Any serious enguirer will make the adjustment as best he can but it could well be done for him.

The London Market has in the past tended to keep its funds in four currencies; UK Pounds, US Dollars, Canadian Dollars and convertible Pounds. All other currencies would be sold for conversion into one of these for the holding of reserves. The original currency is repurchased to cover claims where necessary. However recent developments indicate that many London reinsurance companies intend to commence holding funds in at least four additional currencies, namely Deutschmarks, Swiss Francs, French Francs, and Yen.

In these days of rapid inflation of Sterling the implications of a currency risk being involved throughout the account are considerable.

However, it must be pointed out that there are strong automatic counter effects. Firstly, the holding, in original currency, of premium reserves by the reinsured for accounts not yet closed means that claims yet to arise or be settled are partly covered without a currency risk being involved. Secondly, when this holding is added to balance of account holdings for closed accounts (which means that paid claims have already been deducted) the effect is further strengthend. Thirdly, rates of interest show a not inconsiderable correlation with rates of inflation (though never rising quite so high). Hence the true comparison for a risk written in German DM is a comparison between an investment in pounds earning, say, 14% per annum, and depreciating say 25% per annum (but decreasing) against an investment in DM earning about 6% and depreciating say 5% per annum (but increasing). Fourthly, UK reinsurers have made on the "swings" of South American currencies more or less what they lost on the "roundabout" of European and Japanese currencies over the last few years.

SECTION 5 CLAIMS DISTRIBUTIONS

5.0 INTRODUCTION

In this chapter we present claim data representative of various types of business together with associated fitted curves of differing types to illustrate their effectiveness.

It is widely suggested in theoretical papers that curves fitted to past claims data are useful. However it is important to realise that a fitted curve may be useful only if one type of curve consistently fits recent years data, and there are no wide fluctuations in the parameters between years. It is to be expected that some changes in parameter values will occur, particularly in inflationary times, but for a fitted curve to be applicable to calculations of future claim levels it is obvious that we must have some grounds from which to project parameters, and that the monetary values should not be too sensitive to small changes in the parameters.

* Interest on rederves over and above technical Asterves (in the sclowing mergan)

In the context of a direct writer seeking reinsurance, we require to have an outline picture of the entire distribution by size of gross claims, but we must be particularly sure that our outline of the distribution is as accurate as possible. In deciding on the extent to which business should be retained, one must not mislead oneself into thinking that very large claims are too infrequent. However, in negotiating terms with the reinsurer it would obviously be disadvantageous to assume that too many large claims are likely to occur. The non-proportional reinsurer ought to be aware of claims that have just failed to affect him, say over 50% to 75% of the excess or stop loss level.

Before going further, there are a few important points which should be noted. In applying analysis to claims data it is usually necessary to try to confirm that claims are independent. This may not always be possible; for example several claims — may arise on consequantial loss policies of totally unrelated companies as a result of fire causing damage at the premises of another company which supplies each of them. This is also a particular problem for reinsurers since they frequently discover after an event that claims are being submitted from several ceding offices who were severally involved in the loss.

Since claims such as these may be dealt with by different branches even within one company it is probably impossible for all such cases to be picked up centrally and the interdependence marked. Events involving multiple claims where a marker will certainly be introduced to identify all claims arising from the one event are those, such as widespread violent storms, where the direct writing company soon realises that aggregate claims will warrant making a reinsurance claim.

This type of very large event causes a further problem. Should the particularly large loss, which may be regarded as of catastrophic nature (be it basically one or two large claims such as Flixborough, or a storm causing very many claims such as the January 1976 gales in the United Kingdom or a major United States hurricane) be included in an analysis of claims? The answer to this question may well depend on the size of the company and on the types and levels of reinsurance cover it has. Almost all companies will have some kind of excess of loss per event cover, and might regard any loss above the excess point as a catastrophe for its own purposes.

For a very large company the excess point for this type of treaty will probably be so high that an event of suitable size occurs only infrequently, perhaps every other year say. Such an event will be widely regarded as catastrophic and may rightly be considered totally different from all other events giving rise to claims in the year. In these circumstances it is probably best to exclude such rare large losses entirely from the analysis, whilst still keeping a mental note of their existence. Reinsurance negotiations for catastrophe excess of loss treaties will not be based only on past statistics of the direct writer concerned. Market experience will be used and ultimately terms will be based on judgement and opinion rather than past statistical facts. The possibility of catastrophes should also be remembered when rate reviews are carried out and overall premium income levels required are considered.

For a relatively small company the excess of loss per event treaty may be regarded as providing working cover and <u>some</u> of the events giving rise to claims on it would not be generally classified as catastrophes or even large claims except in the context of the small company concerned. In these circumstances sufficient numbers of events may be occurring each year that all claims affecting the treaty could not be considered untypical of the portfolio and only the really exceptionally large events should be climinated from the analysis for most purposes. (The same comments as above would apply for those few events).

Obviously each class of business must be considered separately. Indeed, it is often best to sub-divide into sub-classes where there are sufficient numbers to justify this.

5.1 TYPES OF FITTED CURVE

In his paper, "The Distribution of Claims according to Size in Non-Life Insurance", (Newsbulletin of Association of Swiss Actuaries 1970), Benktander discusses various mathematical distributions which have been considered suitable for this purpose.

The linear exponential by itself can be used only over a part of the range of claim size. It does not have sufficient skewness to be useful over the full range of claims encountered in most accounts.

An improvement can be obtained by taking an exponential trinomial but there is still likely to be too rapid convergence giving an underestimation of claims at the upper levels.

Alternatively, a log-exponential or Pareto distribution may be used. Here the problems become reversed and it is usually possible to obtain a reasonably good fit to the data only for the tail of the distribution and even then there is a tendency to overestimate the probability of very large claims arising. To obtain a good fit to the data from a direct insurer it is often necessary to truncate such functions.

The log-normal distribution has been used for some classes, in particular, motor, but again often tends to underestimate the frequency of very large claims.

Other more complicated functions have been used at different times by various people. However, it is our opinion that, for practical purposes, it is better to obtain a good fit with a relatively simple function which can then be easily manipulated than to strive for a superior fit by a function which is very awkward to deal with. In any case, it is debatable whether the standard of the data is likely to fully justify the use of highly sophisticated expressions.

5.2 THE FITTING OF CURVES TO UK MOTOR DATA

5.2.1 INTRODUCTION

Data have been obtained from a large U.K. motor insurer. They show numbers of claims above specified values, including paid claims and outstanding estimates, for accident years 1969 to 1972 subdivided according to age of policyholder, comprehensive or non-comprehensive cover. Numbers are shown below using a basic 10,000 claims per annum in each sub-division (including those ultimately settled for nil). Development in all cases is to end 1974.

First of all, we attempted to fit a log-normal curve to the data for comprehensive. The results were not very encouraging.

Claim Year 1960 No. of claims in range. Claim size £	Age of D A		21. • A	- 25 E	26 - A	- 45 E	46 - A	- 60 B
20,000 upwards	4	0	2	о	1	0	о	0
10,000 - 20,000	5	2	2	о	2	0	3	0
5,000 - 10,000	20	6	3	2	5	1	4	1
2,500 - 5,000	4	23	17	9	9	7	10	7
1,500 - 2,500	58	46	20	23	1.6	17	18	17
1,000 - 1,500	35	67	33	44	24	31	30	33
750 - 1,000	69	82	29	57	21	42	2.4	45
500 - 750	120	184	95	141	78	105	68	113
400 500	97	155	106	1.21	77	93	90	99
350 - 400	126	107	94	91	69	72	75	77
300 - 350	151	154	136	125	1.01	101	1.1.5	107
250 - 300	272	216	197	184	1.59	148	171	157
150 - 250	971	872	785	740	646	634	654	659
100 - 150	1044	1062	889	871	843	800	861	806
Mean (fit parameter)		-3.03		-1.44		-2.03		-1.66
s.d. ("")		1.93		1.46		1.55		1.47
Over £5,000	. 29	8	7	2	8	1	7	1

5.2.2 COMMENT ON TABLE 1

TABLE 1

These are numbers of claims per 10,000 notifications within each group separately. The numbers of nil claims vary widely between age groups, from 21-24% for < 21 and 21-25, down to 13-15% for 26-45 and 46-60.

There is an obvious similarity in the patterns for the age groups 26-45 and 46-60.

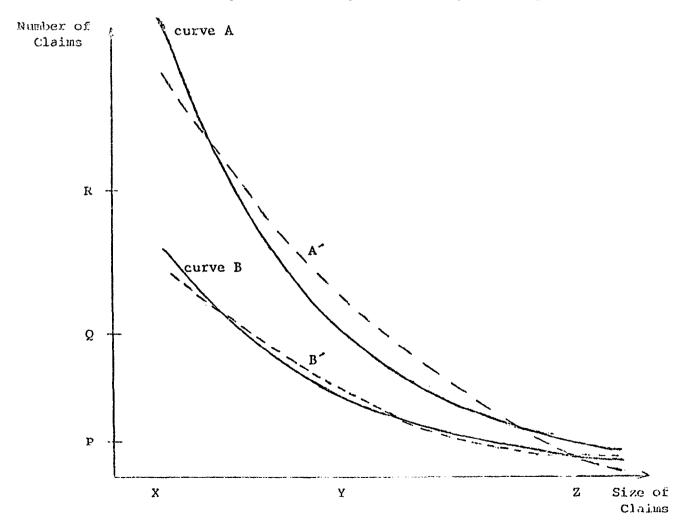
The data used are for claims over £100, but no lower, to reduce the effects of varying levels of policy excess. Rather unusual band widths are used for claim sizes. This is a result of the data being compiled for another purpose and lack of time precluding additional extraction of information and reworking. It would be more usual to employ either bands of equal width (which would not be very suitable for illustrative purposes of such a skew distribution) or bands where the widths increase in geometric progression, (e.g. by a factor of 2 or since a log-normal curve is being fitted a factor of e^{1}_{i} or $10\frac{16}{5}$ say. The latter would give bands with end points 100, 158, 251, 398, 631 and 1,000).

The curve fitting was carried out using the maximum likelihood method given by V. Harding in his paper to the 18th Int. Congress (TICA 18.11 445), making the expected cumulative no. of claims over £100 equal to the number actually observed. The parameters indicate that we are very much in the righthand tail of the full log-normal distribution. Calculations were also carried out for claim years 1970, 1971 and 1972. The patterns are very similar and only small changes occur in the parameters to take account of inflation, and fluctuations.

For example, for age group 46-60	Year	Mean	s.d.
using units of 100	1969	-1.66	1.47
	1970	-1.59	1.48
	1971	-1.45	1.44
	1972	-1.43	1.46

It is obvious from the expected values obtained that these fitted distributions do not have a long enough tail. In fact they tend to have too few claims £100-£250, too many somewhere between £400 and £1,500 and equin far too few over £5,000. Obviously it is this last deficiency which is most important to reinsurers.

Since most large claims are those involving third party injuries, and data were available of payments to third parties only, we decided to fit curves to the data. This proved to be reasonably successful. The reason for this can be shown most easily by an illustration. The sketch below emaggerates the situation, but assume that curve A represents "the actual all-claims distribution" and curve B represents "the actual TP only distribution with curves A' and B' being the best log-normal curves fitted to A and B respectively. Note that curve A is substantially higher than curve B for all small claim amounts but only slightly so for large claims. This imbalance changes the fitted parameters significantly between A' and B'.



We have not marked scales but very approximate values of the points P...2 are

	No. of claims		
Point	10,000	Point	Binoant £
P	10	X	250
Q	100	Y	1,000
R	1,000	Z	2,500

Note : that the above relates to T.P. payments on COMPREHENSIVE policies. T.P. and T.P.F.T. policies are considered later.

TABLE 2

Claim Year 1971 No. of claims	Age of P/H 21	21 - 25	26 - 45	46 - 60
in range Claim size E	7. E	A E	ΛΕ	A E
20,000 upwards	o 2	4 2 ¹ 2	1 11/2	01
10,000 - 20,000	96	2 3	3 2 ¹ 2	32
5,000 - 10,000	10 13	6 7 ¹ 2	54	55
2,500 ~ 5,000	40 31	18 14	9 10	12 <u>1</u> 0
1,500 - 2,500	49 42	17 18	15 13	1.6 13
1,000 - 1,500	30 49	22 21	18 16	18 16
750 - 1,000	10 45	11 20	11 14	13 16
500 - 750	61 79	38 36	30 28	28 29
400 500	89 52	22 25	17 19	16 20
350 - 400	50 33	14 17	12 13	13 15
300 350	39 41	21 22	22 1.3	13 17
250 - 300	60 52	40 29	17 22	31. 24
Mean (fit parameter)	-0.17	-4.18	-3.88	-3.52
s.d. ("")	1.84	2.83	2.70	2.58

5.2.3 COMMENTS ON TABLE 2

The figures on the table are based on numbers of third party claims per 10,000 notifications of all types of incident on comprehensive policies.

Patterns were generally similar over claim years. Age groups 26-45 and 46-60 were again similar and 21-25 generally lay between these and the below 21 group.

Detailed data were not available below £250.

The same method of calculation was used as for Table 1 with the expected cumulative number of claims over £250 made equal to the number actually observed. As before calculations were also carried out on the data for the other claim years and the patterns were basically similar although since a smaller number of observations are involved fluctuations tend to be greater. For example, for age groups 46-60 using units of 100:

Year	Meeti	<u>s.d</u> .
1969	-3.71	2.54
1970	-3.51	2.53
1971	-3.52	2.58
1972	-3.84	2.61

5.2.4 GOODNESS OF FIT AND THE EFFECT OF CHANGES IN PARMETERS

Formal tests of gordness of fit seem out of place. For one thing the sources of variation are many and "sermal" stochastic fluctuation may not be the most important. We have not therefore given values of [], if only because it measures overall goodness of fit and largely ignores systematic deviation such as that between curves A and A' or B and B' and to the reinsurer it is goodness of fit at the extreme tail which is all important. We have however given the quantity $\underline{A - E}$

ln (#2/12)

when UT. and it. are the upper and lower limits of the band and ln is the natural logarithm. The idea was to give a measure of divergence of data from the conversion which was related to the size of the band. This is rough and ready but is better than cruck figures in a series of bands of unequal width.

We go on to calculate the effect of a small change in β for constant β and a small change in β for constant β , the changes being of the order of magnitude of those actually experienced from year to year in the curves we have fitted. The results suggest that the direct insurer is very much less affected by a small change in either parameter than is the reinsurer.

The tablesbelow help to illustrate the fits achieved and the significance of the parameters calculated in Table 2. TABLE 2A

IMBER 274					
	Age of P/H \leq 21	21 - 25	26 - 45	46 - 60	
Claim size £'s	12	1 2	1 2	12	
20,000 upwards	-2 -	+1½ -	-1 ₂ -	-1 -	
10,000 - 20,000	+3 +4	-1 -1.	+ ¹ 2 +1	+1 +1	
5,000 - 10,000	-3 -4	-1 ¹ ₂ -2	+1 +1	0 0	
2,500 - 5,000	+9 +13	+4 +6	-1 -1	+2 +3	
1,500 - 2,500	+7 +14	-1 -2	+2 +4	+3 +6	
1,000 - 1,500	-19 -47	+1 +2	+2 +5	+2 +5	
750 - 1,000	-35 -122	-9 -31	-3 -10	-3 -10	
500 - 750	-18 -44	+2 +5	+2 +5	-1 -2	
400 ~ 500	+37 +203	-3 -13	-2 -9	-4 -18	
350 - 400	+17 +127	-3 -22	-1 -8	-2 -15	
300 - 350	-2 -13	-16	+9 +58	-4 -26	
250 - 300	+8 +44	+11 +60	- 5 -27	+7 +38	

THE EFFECT OF CUARGING PARAMETERS

TABLE 2B

	Age of P/H 21 Age of P/H 46-60			Age of P/H 21			Kanadari a ta kata kata kata kata kata kata kat	
Claim size £'s	1	2	3	4).	2	3	4
20,000 upwords	2	.3	.3	2	1	1'2	1	1.
10,000 - 20,000	4	6	5	5	1. ¹ 2	$2^{1_{2}}$	2	23
5,000 ~ 10,000	.1.2	1.6	15	1.3	35	5	5	3%
2,500 - 5,000	30	33	33	29	9	11	10	10
1,500 - 2,500	38	44	44	40	1.2	15	14	12
1,000 - 1,500	48	51	50	47	15	17	18	15
750 - 1,000	44	45	47	44	14	17	15	15
500 - 750	78	79	81	76	27	33.	31	28
400 500	52	51	53	50	20	21	21	19
350 - 400	33	33	33	33	12	15	1.4	14
300 350	42	40	42	40	18	18	18	17
250 300	52	51	53	51	22	25	25	23
Mean	-0.17	-0.17	-0.12	-0.22	-3.52	-3.52	-3.47	-3.57
s.d.	1.79	1.89	1.94	1.84	2.53	2.63	2,58	2.58
TOTAL	435	452	459	430	1.55	1.79	174	160

Columns 1 and 2 show expected numbers with the same parameter mean as in Table 2 but with 0.05 subtracted from and added to the standard deviation respectively.

Columns 3 and 4 show expected numbers with parameter standard deviation as in Table 2 but with 0.05 substracted from and added to the mean respectively.

5.2.5 NOR-COMPREMENTING COVER

We have so far referred only to Comprehensive cover. Consideration of Non-comprehentive is now a relatively straightforward task since the third party only claims category new covers 90% of the total number of claims for over £250. The general third party patterns are* fundamentally similar (bearing in mind the different number base) to those of Comprehensive although there is rather more fluctuation in numbers between claim years within age groups.

Following from the above results, it seems that the most suitable way to fit a curve to the entire distribution is to use a sum of functions, one of which will converge rapidly, the other, contributing relatively little for small claims, continuing out to provide the necessary tail.

5.2.6 THE USE OF CUEVES COMMANNER MORE THAN CHE COMPONENT

As indicated above, the nature of these functions may be log-normal. Alternatively, a combination of simple linear or quadratic exponentials may be used if the data area a suitable form. See below an illustration based on combined data consisting of paid claims and outstanding estimates for another large U.K. direct motor insurer.

This office operates a folcula system of reserving for small claims and such claims are kept separate for analysis. Approximately 30% of all claims notified are ultimately classified as Nil settlements and approximately 69% by number of all claims notified are ultimately settled for an amount less than £1,000; these account for approximately 65% of the total claim cost. This leaves approximately 1% (by number) of larger claims (not covered by the formula system) being settled for approximately 35% of the total claim amount. The method of classifying claims for formula treatment is now sufficiently established that, although there is a fluctuation in numbers between claim years, the number of claims expected to be over £1,000 for a particular claim year rapidly stabilises.

Data on small claims were not available for this analysis and numbers are shown for accident years 1971 to 1973 using a basic 1,000 claims per annum which are or are expected to be settled for over £1,000. (The values have been adjusted to 1.1.75.)

$$Y = e^{-.38X + 5.50} + e^{-.08X + 1.80} + e^{-.017X - 2.67}$$

provides a reasonable fit to the data for X > 2.5 (£'000s). The first term is dominant for low values of X, the last term provides the tail and the second term is required to give suitable weight in the central section. The mean of this curve is slightly higher than the mean of the actual data, (which for our purpose is on the safe side). The fit is obviously better in relation to 1972 than to 1971 and 1973 for which fortunately fewer very large claims have arisen.

* for the larger claims.

No. of claims in range		ACTUAT,		EXPECTED	FTRS'F CONPANY
Claim size f.'000s	1.971	Claim Yea 1972	•		"ACTUAL" 1971 - 73
1.0 - 2.5	665	713	688	(685)	61.0
2.5 - 5.0	213	154	177	1.64	163
5.0 - 7.5	51	45	59	68	} 90
7.5 - 10.0	21	30	27	31	30
10 - 15	22	29	24	24	23
15 - 20	15	11	11	10	}
20 - 25	4	6 ¹ 2	7	6	2
25 - 30	2 ¹ 2	2 ¹ 2	3	.3 ¹ 2	
30 - 35	3½	2	1	2	
35 - 40	0].]	1,7	13
40 - 50	0	2½	\mathcal{L}_{j}	2	
50 - 60	0	2	0	1.	
60 - 70 70 and over	1 2	1. 2 ¹ -	ı, l	1,2 1,1 ₂	

5.2.7 The "Expected" column uses the same fitted curve for each year in spite of the fact that there was some inflation during 1971-73, and that the larger inflation of 1973-76 will be reflected in the settlement of the larger claims for the earlier years. A case might be made for defining X as:

Original claim x earnings inder year (Y + 3) earnings index year Y

Or, perhaps better, one might fit every year by reducing all claims to a fixed real amount at say mid-1969 by the methods of Section 3.3. The figures for the company in Table 1 have been added as accurately as possible to give a comparison between the two portfolios and are incorporated in the column headed "First Company". They are based, in part, on estimates at the end of 1975 and it is likely that in the long run there will be an increase in the categories over £10,000.

5.3 FIRE

There is a natural sub-division within Fire between Domestic Fire, Industrial and Commercial Fire, and Industrial and Commercial Consequential Loss.

5.3.1 DOMESTIC FIRE BUSINESS

By its nature, this sub-line of business has a very short tailed claim distribution. The vast majority of claims are for very small amounts and probably at least 99% of all notifications will be settled for less than £1,000. Obviously the potential for very large individual claims, over £20,000 say, will depend on the portfolic written as substantial damage to relatively large properties would then be involved.

The numbers of claims over £1,000 should be expected to vary quite widely between accident years (even per 10,000 potifications on a relatively stable portfolio).

For example, see below, the numbers of claims per 10,000 notifications in each claim band for one large U.K. insurer. TABLE 4

No. of claims in range	Accident Year				
Claim size £'000s	1973	1974			
Nil	1385	1311			
0 - 0.5	8329	8448			
0.5 - 1.0	213	148			
1.0 - 1.5	19	31			
1.5 - 2.0	14	16			
2.0 - 2.5	9	10			
2.5 - 5.0	22	21			
5 - 10	7	9			
10 - 15	2	4			
15 - 20	-	l			
20 upwards		1			

Note The relatively large number of nil claims and extremely small claims (representing fees only) shown for these years is partly due to the treatment of claims arising as a result of terrorist activity in Northern Ireland.

This type of distribution is not very amonable to curve fitting, but we feel that by the nature of this subclass a sophisticated treatment is not necessary. The most common types of reinsurance applicable to this subclass of business are likely to be:- overall quota share; facultative reinsurance of a few very large individual risks, and an excess of loss cover for aggregation of claims caused by one event. Although statistical data of various sorts would be required in order to arrange these covers, a detailed distribution of individual claim amounts will not be essential for that purpose.

A distribution which would be useful in respect of this type of business is a percentage severity distribution relating claims to sums insured. It should not be difficult to obtain suitable information but U.K. data were not available for this study.

Readers are referred to published foreign data on this topic by Salzmann and Banasinski and Wanatowski to which the references are given in the bibliography.

5.3.2 INDUSTRIAL AND COMMERCIAL FIRE BUGINESS

Quite of lot of theoretical work has been done on the claim distributions of this business. Much of this work is from the point of view of the excess of loss reinsurer and the Pareto curve:

$$\mathbf{y} = \mathbf{c} \mathbf{1} \mathbf{x}^{-(a+1)}$$

is widely used for the tail - However, due to the highly skowed chang of the

actual distribution with very many small claims, it is usual to apply the Pareto only to the extreme tail, i.e. to the range (m, *), where m is currently of the order of $E = \frac{1}{2} + \frac{1}{2} + \frac{1}{2}$

Before proceeding to examples of actual distributions and fitted curves, we must point out some of the practical difficulties encountered in this area.

The type of distribution of claims and in particular the length of the tail (i.e. number of extremely large claims) will depend greatly on the type of portfolio written by the company concerned. A particular feature of this type of business is coinsurance, (see Section 2.3), and a further complication is the obdieg of part of some rights so written.

On large risks, a large company will usually feel able to accept a much bigger share than a scall company. In particular the writing of such risks will be dependent on the lead being taken by a large or specialist company. The leader is expected to accept a relatively large percentage of the risk, and will carry on most of the negotiations with the insured of the broker on behalf of the insurers. Where a blanket policy is to be issued covering coveral types of risks and several locations it is possible that following offices may have very little up-to-date information on the risks, the present or the claims.

Even on risks where co-insurance is not required the size of the maximum gross acceptance within one company will vary according to the type of risk and the reinsurance methods employed by the company. The effect of these differences is to make the adaptation of a curve fitted to one set of data for use on another basis rather speculative.

5.3.3 THE SELECTION OF PETERTIONS

When the losses of one company are analysed its acceptance and reinsurance policies obviously influence the picture greatly. There is an implicit introduction of a notional maximum claim size (except in catastrophe circumstances). Unfortunately it is not usually possible to fix this value since it will vary with type of risk and is often fixed not in terms of sum insured (which could be considered the maximum possible loss) but in terms of Maximum Probable Loss (PML/See Section 10).

Since the PML can be based only on judgement, losses can on occasion be larger (e.g. when several safety measures all fail to operate). Since underwriters tend to retain a smaller PML potential on so called relatively poor risks than for "good class" risks, and also wish to protect their reinsurers it has been suggested that analysis of claims should be subdivided by type of risk so that the effect of company policies may be better examined. Unfortunately there are so many types of property when subclassified by construction, occupation, position etc., that very little credibility could be attached to the data for one subclass written by any one company however large. If market data are to be used co-insurance problems arise. Reinsurers must try to obtain the best picture they can from all available data.

5.3.4 PROBLEMS WITH SOME PARETO CURVES

Various difficulties occur in the practical application of Pareto curves in this context. This family of curves cannot be suitably fitted over the whole range of a claim distribution, both because the shape of curve becomes unsuitable when data on medium to small claim amounts are included, and because a positive starting claim amount m must be fixed before parameter values λ , c may be found. Also it it is assumed that the it unusable for some purposes. For the ordine fitted distribution (m,) to have a finite mean, it is essential that '' and for it to have finite variance at. Some elegant theoretical work has been presented assuming that, whereas for many types of account this seems most unlikely to arise from curve fitting in practice.

If it appears that in fact the best fitted value for a is less than 2, but finite variance is required, the only practical course is to transate the fitted curve at a suitably high value m (and adjust values of d, and c to compensate). In view of the PML method of limiting net retentions, a value for m may usually be selected allowing a suitable margin for misjudgement so that P[x, m] is acceptably small and such that should a claim of size m or greater occur it would be the result of circumstances sufficient to justify regarding it as a catastrophe (see discussion in Section 1). As an aside we may remark that the existence of such events as Flixborough might coincide with infinite variance, but the practical effect would, surely, be to make a complete mockety not merally of statutory solvency margins but also of the whole concept of insurance. Forticately the real risk must be finite, even if it is very large, and such excussions into infinite variance are unlikely to have much practical value.

The following examples show gross claims (including settled abounts and outstanding estimates) for a very large U.K. direct writer. These give numbers of claims per 25,000 notifications in each year showing own losses before all reinsurance.

5.3.5 PERSONS CURVES TO 1973 DAPA

12.23 CB 5

No. of claims in range	claims in Accident Year 1973 range				a. Is show for the second second
	Actual		Expe	cted	
Claim size.£'600s		A	в	С	D
50 - 100	61	65.7	63.9	60.7	59.6
100 - 150	14	13.0	1.3.5	15.5	15.3
150 - 200	11	4.7	5.1	6.1	6.5
200 - 250	1	2.3	2.5	3.0	3.1
250 - 300	1	1.3	1.4	1.6	1.7
300 - 400	-	1.3*	1.5*	1.6*	1.6*
400 500	_	0.6	0.7	0.7	0.6
500 - 600	2	0.3	0.4	0.3	0.3
600 - 700		0.2	0.3	0.2	0.1
700 - 800	-	0.1	0.2	0.1	0.1
800 - 900	-	0.1	0.1	0.1	0.0
900 - 1000	-	0.1	0.1	0.0	0.0
1000 upwards	-	0.3	0.2	0.1	0.0
Total no.	90	90.0	89.9	90.0	89.9
Mean value	106.3	106.2	106.3	106.5	106.1
* total over 300		3.0	3.5	3.1	2.7

5.3.6 CONTINUES ON UNDER 5

Fitted curves A and B are both ordinary Pareto curves of the type $y = c \otimes x^{-(1+1)}$ They are calculated to give as nearly as possible the correct number of claims over 250,000 with the correct average amount.

Curve A has $\beta = 1.89$ and c = 146,300. Curve B is similar to curve A but is calculated on the assumption of truncation at £1.5m. $\beta = 1.78$ and c = 95,400. The effect of this truncation is to reduce the skewness of the fitted curve. Observe that both values of β are less than the critical 2.0.

Cueves C and D are curved of the following form

H (x) = c a x^{-(1-b)} exp $\frac{\partial x^b}{b}$ = proportion of claims by number exceeding x

This is adjusted to ensure the correct number of claims over £50,000. Again parameters a,b, and c were found to give as nearly as possible the correct average emount.

For curve C, a = 0.185, b = 0.4, c = 516For curve D, a = 0.126, b = 0.5, c = 333

This form of curve gives much reduced skowness and lowers the run off of the extreme tail. However in this region there are so few claims that it is really saying that N x o = o. It was originally put forward by Denktander as a possible way of obtaining a much more realistic tail then the Pareto family (which are too high) and the exponential family (which are too low). Unfortunately, the nature of this expression is rather difficult to deal with unless $b = \frac{1}{2}$. Since the fitting of this type of curve is extremely difficult the values for parameter b of 0.4 and 0.5 were chosen rather arbitrarily as likely to give suitable curves and then values found for parameters a and c. Note that changing b by this amount results in large changes to both a and c although curves C and D are on the whole very similar.

5.3.7 FITTING CURVES TO 1974 DATA

TABLE 6

No. of claims in range			Accident	Year 1974	an a	89, <u>C., I. (. (. (. (. (. (. (. (. (. (. (. (. (.</u>
Claim size £'000s	Actual.	Е	F	Expected G	в′	c ′
50 - 100	50	45.1	53.8	50.6	51.8	49.2
100 - 150	13	13.1	10.4	12.8	10.9	12.6
150 - 200	5	5.8	3.8	4.8	4.1	5.0
200 - 250	3	3.1	1.8	2.2	2.0	2.4
250 - 300	-	1.9	1.0	1.1	1.1	1.3
300 - 400	2	2.1*	1.0*	1.0*	1.2*] 3*
400 - 500		1.1	0.5	0.4	0.6	0.5
500 - 600	-	0.6	0.3	0.1	0.3	0.3
600 - 700		0.3	0.1	0.1	0.2	0.1
700 - 800	-	0.2	0.1	0.0	0.2	0.1
800 - 900		0.2	0.1	0.0	0.1	0.1
900 - 1000	-	0.1	0.0	0.0	0.1	0.0
1000 upwards	1	0.5	0.1	0.0	0.2	0.1
Total no.	74	74.1				
	(73)		73.0	73.1	72.9	73.0
Mean value	135.7	135.7				
	(99.7)		99.9	99.7	106.3	106.5
* total over 300	a ga mananan kanan k	5.1	2.2	1.6	2.9	2.5

5.3.8 COMMENTS ON TABLE 6

The very large claim shown as over flm in 1974 was Flixborough and may be regarded as being in the catastrophe category.

Curve E is of the same form as C and D above with a = 0.180, b = 0.3, (selected arbitrarily) c = 599 and it attempts to fit the data <u>including</u> the Flixborough claim. This is not very satisfactory and all the other calculations were carried out on the basis that this claim was exceptional and was excluded from analysis.

Curves F and G are similar to curves B and C respectively but fitted to the 1974 data.

Curve F has d = 1.92 and c = 133,700Curve G has a = 0.142, b = 0.5 c = 372

Curves B' and C' are scaled versions of curves B and C to allow for the different numbers occurring over £50,000. This illustrates the need for several years' data to be analysed before 'safe' parameters may be fixed, (since 1973 values would in fact have proved on the safe side for 1974* but dangerous conclusions might have been reached if the results had been vice versa).

5.3.9 COMPARTSONS OF TWO INSURERS

We now illustrate the point mentioned above concerning the vastly different pictures which may be obtained from claims distributions of different companies. Below is a comparison of claim distributions for the very large company P and a much smaller company Q which writes broadly the same types of industrial and commercial risks but is limited to net retention levels which are only approximately 0.25 or 0.2 of those of company P. The figures are given adjusted to a common basis of 10,000 notifications per annum to each.

TA	BLE	7

No. of claims in range	Accident Year 1973		Accident Year 1974	
Claim size £'000s	Р	Q	P	Q
0 - 5 inc Nils	9604	9801	9673	9832
5 - 10	163	117	159	98
10 - 15	64	45	45	37
15 - 20	43	17	36	1.6
20 - 25	27	8	18	8
25 - 30	13	6	14	5
30 - 40	33	3	15	2
40 - 50	17	2	11	2
50 upwards	36	1	29	о

5.3.10 COMMENTS ON TABLE 7

Obviously the fitted curves derived above for the large claims of office P would be useless for Office Q, although similar formulae may well apply with different parameter values to the distribution of its largest claims.

Unfortunately, we have not been able to obtain industry figures in a suitable form for comparison with the figures in table 7.

It seems that if it is required to fit a curve to the entire range of an industrial fire claim distribution, a method of summing terms (see Section 5.2.6.) is most likely to give a good fit. The nature of the terms and the values of parameters will obviously depend on the company concerned and type of portfolio written.

U.K. No/data appear to be readily available linking claim size to sum insured size for industrial or commercial fire risks. For such data to be useful it would seem that it would have to be subdivided by type of risk (e.g. the loss severity distribution for office blocks is almost certain to be different to that for petro-chemical works). This implies that market statistics will have to be produced. Unfortunately, although it may seem simple to decide on a sum insured value relating to each claim, it is in practice quite difficult to establish this in some cases and almost impossible to give figures for exposure. In particular, for very large client companies it is often the practice for the insurers to issue a blanket policy which will provide cover for many buildings at many sites and for their contents with a total sum insured declared but very little information given about other than a few target risks. The leading insurer will have to obtain certain data but those following will possibly receive little information. In any event, if a fire occurs in one of several buildings at one of several large sites which are covered under a blanket policy it may be very difficult to decide which sum insured value should be used in the analysis - the value of the building damaged; the value of that building and immediately adjacent buildings; the value of all buildings at that site; or the value of all buildings at all sites. (Plus a comparable amount for contents with the additional complication that for some risks, amounts of stock stored at each site may vary widely from time to time).

5.4 CONSEQUENTIAL LOSS

It is obvious that many of the comments made above regarding Industrial and Commercial Fire claims distributions will also apply to consequential loss. In fact this class of business probably accentuates the problems, since far fewer claims are notified per annum. The vast majority by number of claims will be for small amounts but the occasional very large claim occurs and can distort the picture. The types and sizes of risk accepted for cover obviously affect the number and sizes of claims. It is probably fair to say that even the largest offices do not have sufficient consistent data for curve fitting to be usefully applied. For example, see below the distribution of gross claims per 1000 notifications per annum to one large U.K. insurer. Inflation accounts for some of the trend to higher values of course, but we have no way of knowing how much of the variation is mere fluctuation and how much is due to changes in the underlying shape. In any event, projections based on data for 1971 and 1972 only would have proved very inadequate for 1973.

No. of claims in range		Accident Y	ear
Claim size £'000s	1971	1972	1973
0 - l inc. Nils	860	823	802
1 - 5	92	128	119
5 - 10	23	22	31
10 - 25	12	18	23
25 - 50	8	6	13
50 - 100	2	2	8
100 upwards	3	1	4
Over 10	25	27	48

TABLE 8

6.0 CATASTROPHE RISKS - PROVISION BY THE DIRECT WRITER

For a class of insurance business where the possibility of a catastrophe exists, a proportion of the premium charged for each risk should be considered as required to provide for the occurrence of catastrophes. Since even for the largest insurer a catastrophe cannot be expected to occur every year, it is necessary for an insurer to take special action to provide for such an event when it does occur. This can take one of two forms. Either the insurer can pay a proportion of the premium to a reinsurer to cover the catastrophe risk, or a special fund can be set up to meet catastrophes, when they occur. In the latter case, a proportion of the premium (similar to that which would be alternatively paid to the reinsurer) should be set aside each year to build up the special fund. Drawings from the fund should be on the basis of a predetermined definition of a catastrophe.

Some types of policy are prome to produce catastrophe situations as a result of a series of claims arising from a single policy, due to a single event. This applies to such classes as products liability and contractors liability. Examples of possible situations giving rise to catastrophes can be envisaged in the manufacture of such items as drugs, fertilisers, vehicle components and building materials. A faulty batch of such products can result in a multitude of expensive claims falling onto the manufacturer. Construction faults are likely to produce a much more localised pattern of claims, but the collapse of a motorway bridge (or even a series of such bridges) due to faulty workmanship or design (High Alumina Cement for instance) could lead to a serious aggregation of claims, as in a catastrophe.

6.1 PROVISION BY REINSURANCE

As all such claims arise under only one policy, they are likely to fall on one insurer. However, in addition to the usual provisions for catastrophes, such policies are often reinsured on a layer basis to provide a more equitable spread of the cost over the insurance market.

A typical layer arrangement would be for one insurer to bear the first fl00,000 of any claim (all claims under a single event being considered together) and then a group of (say) 5 insurers sharing the next £700,000 (say) of the claim and another 10 insurers sharing any payments in excess of £800,000.

When underwriting a catastrophe risk, the Underwriter will have the following considerations to apply:

- (a) Some idea of the underlying portfolio the number and type of Risks involved.
- (b) Any available basic technical data such as the detailed geographic analysis of earthquake risks produced by the ROA.
- (c) A knowledge of what catastrophe statistics are available, world-wide, over 5 or 7 years.
- (d) Some idea, probably mainly intuitive, of the statistical analysis underlying Excess of Loss Risks.
- (e) The past results of his own Syndicate statistics for that class of business, bearing in mind the possibility of abnormally large claims at long intervals of time.

6.2 LLOYDS UNDERWRITERS

The main danger in the Lloyd's system lies in an accumulation of risks. Where the Reinsurer cannot "see through" his portfolio due to a lack of information from direct writers, he is unaware that risks may be accumulating heavily in one area and in any case it is difficult to avoid. Personal accident insurance on an aircraft, written before the journey commences but only known to the Insurer afterwards, can be handled in the light of experience. Fire comprehensive insurance cannot.

The Betsy hurricane in the USA in 1965 and the more recent Darwin disaster have affected Lloyd's (as well as some of the company market) heavily. Statistics are built up of those disasters through the use of "catastrophe" codes but they do little more than pin-point the related claims.

A more important problem, which no one can see any chance of solving in the near future is the coding <u>in advance</u> of risks that may produce associated claims, at least other than on a very broad basis.

Mainly due to the effect of accumulations of risk it is understood that a Lloyd's Syndicate tends to suffer a major loss perhaps once in 8 or 10 years, with a minor one every three or four years, a fairly even loss ratio in between, and some cyclical swings according to the level of premium income at which risks are placed. The position should be handled by the building up a large reserve fund. The dependence of the Syndicate on underlying "names" whose composition changes from year to year prevents this nominally as the fortunes of the Syndicates are supposed to be completely closed and charged out, for each underwriting year, at the end of the third year of development. However, "names" tend to be fairly stable, the Lloyd's audit system encourages the holding of ample reserves and some measure of reserve fund tends to be built up, usually only partly sufficient.

Furthermore there are special tax arrangements (although only partially effective) to enable a "name" to set up his own reserve fund out of past profits.

6.3 CATASTROPHE STATISTICS FOR 1974/75

Each year, in the January edition of their publication, Sigma, Swiss Reinsurance Company (UK) Limited lists the major catastrophes and insurance losses for the preceding year. These are worldwide and, whilst admittedly not comprehensive, include, for the years 1974 and 1975, events which have resulted in the loss of 20 or more lives or cost in excess of about f2m sterling or its equivalent. There will be some ambiguity in cost between total direct damage and insured losses including consequential loss where relevant. In third world countries insured losses may be only a very small proportion of total damage whilst in highly industrialised countries they could well be of the same order of magnitude or even exceed direct damage. The valuation of the costs involved does not seem to be entirely consistent, as in some cases insured losses are being measured, whereas in others the total estimated loss is given.

Against this background it is difficult to draw definite conclusions but the frequency of such events is fairly consistent, in that 132 are recorded in 1974 and 128 in 1975. However, there are significant differences between the numbers in each month, in particular January and September having high numbers, whereas October and November have low numbers in both years. It would need data for several years to determine whether these are statistically significant. Furthermore, even if there are variations from month to month they may have little practical significance for rating if this is on a calendar year basis. The effect on cash flow might be more important.

6.3.1 AVIATION AND MARINE

Aviation losses emerge very consistently at about 7 per quarter and losses recorded in the 2 - year period resultation the loss of over 3,000 lives. 40% of the recorded losses look place in the developing areas of South America and the Far East. Whilst data on aircraft movements are unreliable it seems likely that this is guite out of proportion to risk whether measured in aircraft miles, passenger miles, or the number of take offs and landings.

Marine losses fall into two clearly defined categories - accidents to passenger craft, involving heavy loss of life, mainly in the Far East, and losses involving ocean-going ships where the main reason for inclusion is property loss that is of the hull and cargo rather than drew and passengers. On average about 2 incidents per month are recorded. Many of the financial losses concerned ships involved in the transportation of oil, including the largest recorded loss, that of the "Kriti Sun" in the Straits of Malacca after being struck by lightning. However, the even more costly loss of the "Berge Istra" is not recorded, because the loss was not discovered until January 1976. 36 road and railway accidents were recorded, the majority involving buses in the Third World. There are several bus or coach crashes in Western Europe, and the railway crashes include two in underground systems. In every case the criterion for inclusion is loss of life.

6.3.2 STORM, FLOOD, EARTHQUAKE ETC.

Over 30 events are listed which fall into the general category of storms. This is taken to include hurricanes, tornadoes, typhoons and cyclones. The most serious of these ranks as the greatest catastrophe in the 2-year period, both from the point of view of loss of life and financial impact. This is hurricane "Fifi" in Honduras in September 1974, which cost 10,000 lives and over £200m. In April of the same year, tornadoes in the Southern States of USA cost nearly as much but with a much lower loss of life. One feature which is particularly obvious is that nearly half of the losses recorded took place in USA, and the majority of the remainder in either Central America or the Far East, the areas traditionally associated with hurricanes and tropical storms. A similar number of flooding incidents is shown, again with large numbers in South America and the Far East. One feature which is particularly remarkable about the incidence of the floods is that over 40% of those recorded occurred in the 3rd Quarter of 1975. Loss of life ranged up to 2,000 in one occurrence in Bangladesh and homelessness to many hundreds of thousands but in only one instance is a very large insurance loss recorded as a result of the floods following Cyclone Wanda in Australia.

This useful publication reminds insurers that they should be aware of the possibility of substantial catastrophe losses from a wide variety of causes throughout the world. The point is particuarly illustrated by the inclusion of a major flood in North Yemen - hardly an area where such an event would be expected.

Other natural catastrophes included are earthquakes, landslides and an avalanche. Whilst no more than 10 of these are recorded, they do include two earthquakes of very substantial proportions - those in Pakistan (5,300 dead)

and Turkey (2,300 dead). As the majority occurred in underdeveloped areas, financial losses are not recorded.

6.3.3 FIRE

The other main cause of loss shown in the list is fire (with or without explosion). There is a fairly smooth flow of almost 2 such incidents a month, mainly involving substantial financial loss. It may seem somewhat surprising that approximately two-thirds of the incidents recorded took place in Western Europe compared with under lo% in North America. In particular Netherlands, France, England, Denmark and West Germany individually had at least as many fire incidents recorded as USA. Whilst there were a few fires involving heavy loss of life, mainly in buildings used for accommodation or entertainment of the public, the majority of losses occurred in industrial buildings. A wide range of industries is included, but the largest group is in that covering chemicals, including plastics and oil. Flixborough is, marginally, the largest loss recorded but four other losses of over £20m or its equivalent include a similar explosion in Belgium.

What seems to us to be worthy of note is that the overall pattern seems reasonably stable and it could well be that these incidents should be taken out of normal distribution of claim amount and treated separately for reinsurance.

7.0 THE BASIS FOR FIXING MINIMUM STATUTORY SOLVENCY MARGINS

The Insurance Companies Acts provide for minimum solvency margins related solely to the amount of the net retained promium income for the year last ended. They have no regard to the nature of the underlying risks and levels are the same for direct insurers and reinsurers.

The fluctuations in experience which affect the actual solvency margin are partly random and partly secular. The former require a solvency margin which increases roughly as the square root of the number of risks (assuming the spread is unchanged) but adjusted for changes in the average claim size, whilst the latter requires a margin roughly proportional to the technical reserves which may vary from a small fraction of one year's premiums (domestic property cover) to several years' premiums (liability or professional malpractice).

It should be immediately obvious that, with the extremely wide variation in the sizes of insurers, the statutory formula is liable to be a poor, often a very poor, approximation to the desirable margin even allowing for the extra margin required from those with small premium incomes. With reinsurers, whose technical reserves are likely to have a much larger ratio to premiums than for a direct insurer, and where errors in estimation are likely to be relatively much greater also, the difference can be very pronounced.

7.1 IDEAL BASIS IS IMPRACTICAL

If technical reserves are equal to 2 years' gross premiums then, given the size of stock exchange fluctuations in recent years, a solvency margin of the order of 100% of written premiums *could* be required if insurers had much of the margin invested, as would seem not unreasonable, in equities, properties or other hoped-for hedges against inflation.

Margins for the other uncertainties, for example adverse claims development with high future inflation or change of laws (unless the reinsurer was known to be protected against such risks) might require a further similar margin. It is at once obvious that it is totally impracticable to provide margins of even a quarter of this level out of current surplus. It would seem therefore that any attempt to set minimum solvency standards on a wholly rational basis might well have the effect of making most reinsurance and some direct business virtually impossible.

The situation is made even more difficult than it need be by the taxation system. This works against the industry in two ways - firstly solvency margins can be built up only out of income after tax, and secondly inflationary growth in investments (if achieved) is liable to be reduced by the application of capital gains tax to something which does not represent a real gain. The effect of taxation on actual solvency margins is adverse also in indirect ways. Since proper technical reserves are allowable before calculating taxable profits there is an incentive to incorporate some margin in them, and since it is not always easy to convince an Inspector of Taxes of the proper provision for IBNR claims there is a danger of over-payment of tax. In the case of some cover, such as earthquake or windstorm, where major claims do not arise in most years, it should also be possible to create suitable "catastrophe" reserves out of income before tax.

7.2 THE PRACTICAL SOLUTION TO LONG-TERM SOLVENCY

The solution adopted in practice seems to be to ignore most of the possible sources of variation and to adopt arbitrary but conventional margins. In view of the long time scale this scens to have worked fairly satisfactorily. Since it is likely that a market will be required for a long time to come there should be a reasonable chance of adjusting for past losses by increasing future premiums to levels above those which would otherwise be required. If the alternative is to have no reinsurance then cedants will have to pay up unless some outsiders decide to enter the warket and quote lower premiums, being unhampered by past losses. Fortunately a period in which heavy losses are encountered seems to deter new entrants who are unlikely to have any reliable data on which to base their premiums.

7.3 THE PROBLEMS OF SUPERVISION

The Department of Trade has three main problems in regard to reinsurance -

- (1) Is a UK based reinsurer solvent?
- (2) Does a UK direct writer have enough reinsurance cover, both in regard to range of cover and range of peril?
- (3) What is it to do about that part (often a large part) of reinsurance premiums paid to insurers situate outside the UK?

7.3.1 THE SOLVENCY OF A UK REINSURER

The problems of verifying technical reserves are far harder than for direct insurance especially in those classes where few or no payments are made during the first few years after a claim. The early build up of payments is non-existent in the very years when reserves should be at a peak. It is difficult enough for the insurer himself to make a reliable estimate, as is evident from papers by several reinsurers.

For a Supervisory Authority it is bound to be even harder.

7.3.2 THE COVER HELD BY A DIRECT WRITER

The complexity of arrangements by many direct insurers is such as to make it very difficult to check whether every abnormal happening is provided for; this is difficult enough for the Company but is virtually impossible for a Supervisory Authority

Lloyd's is however a special case. Each "name" must have liquid securities of £75,000 and must deposit £10,000 of which the first £5,000 does not count towards fixing the maximum premiums acceptable by the syndicate in any year. This ceiling is ten times the remaining deposits of syndicate members.

The audit requirements are set out precisely, although as we saw earlier they may not always be adequate. However, the Lloyd's quarantee fund is available in case of need to ensure payment of claims. For these reasons most Supervisory Authorities accept Lloyd's underwriting without question.

7.3.3 REINSURERS SITUATE ABROAD

There is very little that a Supervisory Authority can do other than rely on the authorities in the country of the reinsurer. As we have seen their efforts can be of very limited value and there are the additional complications, in case of need, in taking action in foreign courts.

The practical answer to all three problems is that there is very little that can be done, unless the Supervisory Authority is able to obtain, and understand, information relevant to the problems. The returns made under the 1968 regulations in regard to reinsurance turned out (predictably) to be a farce. Whether the 1976 (? 1977) ones will be any more useful in regard to reinsurance remains to be seem. It appears that the E.E.C. have given up the struggle and no longer attempt to exercise any real supervision of professional reinsurers!

7.4 SUPERVISION BY MARKET FORCES HAS WORKED IN THE PAST

Whilst these comments will give little comfort to those who think out every action is to be controlled and guarded, it must be borne in mind that in spite of the violent changes and strains of recent years it is still possible for reinsurers to exist, and for almost any reasonable cover to be obtained. Actuaries should beware of endeavouring to explain in too much detail a system which seems to work well in spite of the apparently impossible conditions, and our intervention must be a modest one, at least until we understand a great deal more about the subject.

8.0 BASES FOR RATING REINSURANCE

8.1 FACULTANT VE

For this method of reinsurance rating and policy wordings are set by the coding office. The reinsurer has all details of the risk being reinsured, but the problem of rating directly concerns him only when he is considering which risks he should or should not accept, at the rate predetermined by the ceding Company. Thus the control of profitability by the reinsurer cannot operate through rate fixing but only through rejection of offers made by the ceding office or by adjusting return commission or profit sharing. Reciprocity also enters into the picture since profitability can be affected by the need to accept risks in order that other risks may be placed in exchange.

8.2 PROPORTIONAL BY TREATY

The reinsurer takes the risks on the terms and conditions allowed by the ceding office when insuring the risk. Cover over the retention level is ceded to the treaty and because the retention levels, in the case of the surplus treaty, may vary from risk to risk there could be some adverse selection against the reinsurers, in compensation the acquisition costs are very much less for the reinsurer than for the ceding company. In the case of Quota share reinsurance where a constant proportion of all risks is placed on the treaty, this selection cannot exist.

Reciprocity may again affect profitability with treaty being traded for treaty. Reciprocity may also tend to inhibit the cedant from taking advantage of the possibility of adverse selection mentioned above, the underwriter being both to place poorly rated risks on the treaty since this might effect the "trading power" of the treaty.

8.2.1 CONTROL OVER PROFITABILITY

The reinsurer has no control over the risks accepted or the rate charged, but he can control the profitability through the return commission paid. This is usually achieved through one of two devices. The first is a flat rate commission representing a contribution to the expenses of the ceding company, plus a profit commission which is a percentage of the average profit over a past number of years. The latter is used to control profitability of the treaty. The flat rate commission may be of the order of 20% to 40% depending on the class of business and the profit commission perhaps 25% of the average profit (or loss) for the last three years. The effect of profit sharing is to smooth to some extent any random fluctuation in the experience. This device is more commonly found on property treaties where a firm estimate of the experience is more quickly reached than on accident treaties.

The second is a sliding scale of commission dependent on the claims ratio achieved, and subject to a specific definition of "claims ratio".

Claims	Ratio
--------	-------

Rate of Commission

at least	less than	
	46%	42-28
46%	47%	42%
47%	48%	41 ¹ 2%
48%	49%	41%
etc	etc	etc
65% or mo:	re	32 ¹ 2%

A possible scale, which penalises the direct writer whose treaties have a loss ratio considerably less than 46% whilst favouring those well in excess of 65% is given in the above table. This method does not smooth the reinsurers results to the same extent as the average profit commission method. A sliding scale profit commission is sometimes used in the form of a hybrid of these two methods.

If the results of a surplus treaty are consistently poor because there is a predominance of under-rated risks placed on the treaty, the reinsurer may well demand a Quota share arrangement in order that its own experience might more closely follow that of the ceding office. Alternatively the experience could be reflected by the application of a less favourable return commission.

8.3 EXCESS OF LOSS WORKING COVERS

Excess of loss treaties may be divided into two broad categories, working covers and other covers. A cover is a working cover if, and only if, the proportion of claims exceeding the excess point is significant, for example if it is in the region of 1/10th% to 1/5th% of all claims. This would correspond to excess points in the region of £10,000 to £20,000 at the present time for a UK Motor portfolio. Other covers include two quite distinct cases. The first is the excess of a very large individual loss, for example a serious bodily injury claim in liability or motor. The second is stop loss cover on an accumulation of associated losses, for example property claims in storms.

8.3.1 BURNING COST RATINGS

A very common method of calculating a premium to cover losses under a treaty is to use a burning cost method.

The "burning cost" of a treaty is the amount required to cover only the claims cost arising during a treaty year.

The burning cost rating method involves calculating burning cost rates over a number of past years, as if the cover being rated had been in force throughout, obtaining therefrom an estimate of the burning cost for the treaty year being rated.

For instance, the losses which would have affected the treaty over the last five years might be £20,000, £25,000, £35,000, £35,000, £145,000 with written premiums of the ceding company in the corresponding years being £1,750,000, £2,000,000, £2,250,000, £2,500,000, £3,000,000. Thus the burning cost rate for the whole period would be

20,000	+	25,000	+	35,000	+		145,000
1,750,000	+	2,000,000	+	2,250,000	+	2,500,000	

= 2.26%

The above account has expanded considerably over the five year period and too much emphasis might be given to the final year in the above approach. This is more important where claims fluctuate considerably from year to year. It could be better to average the rates from year to year, unless one or two years have very small premiums.

Thus the rates are 20,000 = 1.143% 25,000 = 1.25% 1,750,000 = 2,000,000

 $\frac{35,000}{2,250,000} = 1.556\% \qquad \frac{35,000}{2,500,000} = 1.4\% \qquad \frac{145,000}{3,000,000} = 4.83\%$

giving an average burning cost of 2.04%.

8.3.2 EFFECTS OF INFLATION

Another problem is that of the past claims which would have affected the cover. With inflation these claims are at different levels from year to year and as time progresses more and more of the claims distribution will exceed a fixed monetary retention. An answer to this problem is to rebase all claims, (including those below the retention level) and premium figures, to a common currency (say, the currency of the treaty year being rated) using a suitable inflation index before performing the calculations (see Section 3.2).

In many cases the reinsurer, to avoid more and more claims being put on his account, will insist that the recention level be index linked. In determining the cost only the claims exceeding the retention level applicable should be rebased to the common currency.

Worldwide covers give rise to a problem similar to the one of inflation i.e. one level of currency not being used throughout. All claims could be rebased at the local inflation rates and then converted to one currency. This may however be impracticable where many different countries produce the overall claims.

8.3.3 MARGINS

Having derived the expected claims these must be adjusted for Expense and Profit to arrive at the premium to be charged.

This is usually done using one overall loading which will provide a safety margin as well, to compensate for fluctuations in claims.

The safety margin is required for several reasons

1. The burning costs have been calculated on estimated claim amounts to some extent. The claims on the treaty are the larger claims and as such may take a considerable time to settle. Inaccuracy in the claim estimates as a whole will be magnified in the claim on the Reinsurer by the deduction of these retained portions of the claim. It should however be borne in mind that in some classes of business underestimation of the large claims seems widespread, whereas in others there is a strong tendency to overestimate. Motor and medical malpractice seem to come into the first category and fire into the latter. Why this should be so persistent is by no means obvious.

- 2. Changes in risks, underwriting practice/mix of business may adversely affect the treaty. They will often be dealt with in the safety margin but may also be allowed more specifically if details are available. They could, of course, benefit the reinsurer.
- 3. The effect of inflation on the claims may be considerably greater than expected.
- 4. Random fluctuation of claims experience, again exaggerated by the deduction of the retained portion of the claim.

Expenses are small, there being little administration and few claims. These are normally swamped by the safety margin loading. Likewise profit margins are not usually included specifically but are incorporated with the safety loading. The overall loading might typically be <u>100</u> or <u>100</u>

70

03

8.4 EXCESS OF LOSS OTHER THAN WORKING COVERS

The bases for rating excess of loss or stop loss contracts commonly used is a percentage of original gross premium income (OGPI). This is regarded as the best available measure of the reinsurers risk. The potential unsuitability of the OGPI as a basis for rating these covers can be shown by contrasting comprehensive and non-comprehensive motor insurance. The excess of loss risk is much the same for two similar groups of vehicles and policyholders, whether they are insured comprehensively or not, at least so long as the excess of loss limit is rather more than £2,000. Since the OGPI's are in a ratio of about 2/1 it is obvious that the same fixed proportion of each OGPI cannot be a proper measure of the risk in both. Market practice here is somewhat crude but unless a ceding company has a very unusual distribution of business between comprehensive and noncomprehensive, it is quite likely that other uncertainties in the risks render any great precision pointless. It must be remembered that the reinsurer has little or no information on the current portfolio being reinsured.

8.4.1 EFFECTS OF INFLATION

It must also be remembered that OGPI might be quite inadequate for the risk written by the direct insurer himself because of the effects of inflation or for other reasons. The reduction of this problem into its component parts by separating the effects of inflation from those of random variation is an essential first step in the process of estimating reliability of forecast claims on which the premium rating must be calculated.

This reduction of the problem into its component parts is much more important in the case of excess of loss reinsurance since the average delay in making excess of loss payments is much greater than the average delay in making payment of the smaller direct claims which do not exceed the retention limit. The effect of a high rate of inflation on this longer delay is to greatly increase the premium required to provide for excess of loss reinsurance. This effect operates both through the longer period during which inflation increases the claim cost and through those claims that would have fallen below the retention level in the absence of inflation but are raised above it solely due to inflation. The appearance of these additional excess of loss claims can be eliminated by the indexing of the retention level as explained in Section 9.

9.0 THE EQUITABLE SHARING OF COSTS IN CHANGING CONDITIONS

Reinsurance is primarily used in practice by the codent as a means of reducing the effect of fluctuating claims experience on the profitability of a given class of business. Its use is therefore encouraged by the current one-year accounting practice. The fortunes of the reinsurer should broadly follow those of the cedant if capacity is not to be reduced by the reinsurer leaving the market.

9.1 DELAY CORRELATED WITH SIZE OF CLAIM

An inherent feature of reinsurance is that there are delays at each stage between the collection of statistics, the assessment of reinsurance premiums and the occurrence, notification and final settlement of claims to be met out of such premiums. During these delays the frequency and amount of claims arising under any reinsurance arrangement will be influenced by unforeseen or unquantifiable external factors, such as,

inflation or deflation, technological development, medical "advances"*, political factors, changes in legislation or jurisprudence, and changes in social attitudes. They are not, of course, mutually exclusive. In general, large claims take longer to settle than small claims and therefore have a greater exposure to such factors. Non-proportional reinsurance is normally concerned with relatively large claims and the extent to which a reinsurer shares in any loss (or profit) caused by such external factors depends on the level at which the covers operate.

9.2 INEQUITY CAUSED BY FIXED RETENTIONS

A distinction may be drawn between proportional reinsurance (most facultative reinsurance, quota share and surplus treaty) and non-proportional reinsurance (excess of loss, step-loss). Under proportional reinsurance the reinsurer's results will broadly follow those of the cedant for the same risks, subject, in a surplus treaty, to the qualification that external factors do not exert a differential influence on the risks ceded from risks not ceded. This is not the case in non-proportional reinsurance.

Where under a non-proportional treaty the underlying retention, and the various cut-off points (where the cover is in layers) are of fixed monetary amounts it is evident that the respective exposures of each party will change according to changes in the frequency distribution of claim amounts.

As a simple example, a direct insurer arranges an excess of loss treaty under which the reinsurer pays that part of every claim which exceeds £18,000. Suppose that a given claim arising would then have been settled for £24,000 and that three years later when it is settled such a claim costs £32,000 owing to inflation and other factors. The reinsurer's liability has risen from £6,000 to £14,000 whilst that of the cedant has remained unchanged at £18,000.

This example shows how claims escalation has a much greater effect on the reinsurer than on the cedant since the total amount beyond the fixed retention limit is passed on to the reinsurer. In times of claims escalation the technical equilibrium of the parties to an excess of loss treaty with a fixed retention limit is upset, i.e. the relative exposures which existed when the treaty was arranged alter over time.

* We put this word in quotes since in some cases medical care succeeds in keeping alive persons who would formerly have died; often they will recover fully, but at other times they are only technically alive and require constant care and attention, the cost of which may fall in the first place on the insurer or perhaps more often on the reinsurance market. The financial effect on the As claims escalation increased during the sixties so the disproportionate losses borne by the reinsurers became more apparent. Of a number of solutions which were tried the one which has been most commonly adopted has been the index clause or stability clause.

9.3 AN INDEX CLAUSE TO SHARE THE BURDEN OF INFLATION

An index clause is intended to be a provision for automatically amending the Personal Injury cover so that the amount of a claim at the date of settlement is apportioned between the cedant and reinsurer in the same ratio as would have applied at the inception of the treaty, having regard to the inflation which has taken place between that date and the date of final settlement (or the date of a court settlement, depending on the wording of the clause).

An index commonly used for UK liability classes is that for hourly wage rates of workers in manufacturing industry; an Index of Earnings in manufacturing industry is an alternative.

Although external factors other than inflation affect the specific loss under a particular cover an index is generally folt suitable as a basis for arriving at a reasonable and equitable solution towards meeting the underlying principles of excess cover that the relative positions of both parties to the contract should remain unaltered throughout the period of the cover.

Taking the example given above if the index rose from 90 to 120 between inception of the treaty and eventual claim settlement the effective retention limit at the date of settlement would be increased by one-third to £24,000 resulting in a reinsurance claim of £8,000 or one-quarter of the total claim, the same proportion as that applying at inception.

9.4. SPECIMEN INDEX CLAUSE

We give, in an Appendix, some clauses from a Reinsurance Treaty where an index clause has been incorporated. It would not, we think, be unfair to describe this more or less as a declaration of intentrather than a set of legally enforceable clauses. Whilst this might seem at first sight to be undesirable it must be recognised that there is, and always must be, a great deal of mutual trust between parties to a reinsurance treaty and any attempt by either party to construe or enforce such an agreement in a way that was clearly unfair would most likely prove to be of great embarrassment to the party seeking to take that unfair advantage.

For example, Clause d(iv) as worded, could easily be used, or misused. Consider for example a treaty with an excess point of £50,000 where the index is 100. If we make one payment of £120,000 at a time when the index is 120 then the limit has become £60,000 and the claim is paid half by the direct writer and half by the reinsurer. But suppose when the index is 240 the claimant gets an extra £10. The index point is now £120,000, the total claim is £120,010 and all the reinsurer pays is £10! There is the further problem of recoveries. The insurer, may, if it is a motor claim, have to pay because of the condition of his authorisation, even though he has a right of recovery against his own insured. If, subsequently, he gets some of his payment back, does this count as a further "payment" for the purpose of reviving the index clause? There might be a payment (of costs) in an attempt to recover, with the same effect.

In practice we would expect to reach a satisfactory settlement without trouble but the reader must be warned that to attempt to provide for every contingency is almost certainly impracticable and there is no real substitute for honesty and fair dealing.

9.5 EXAMPLES OF THE APPLICATION OF AN INDEX CLAUSE

Partial payments need cause no particular difficulty if proper provision is made in the wording of the index clause. There are many ways of dealing with the problem and further complications may arise where there are recoveries for any reason. The problem of periodic payments is more complex and will be considered later.

Let us now consider a particular case in which

TOTAL PAYMENTS	£24,250	
Indexed payments	£15,000	index = 150
Indexed payments	£5,250	index = 1.05
Unindexed payment (for property damage)	£4,000	
Excess of loss retention	£10,000	index = 96

Three solutions we have seen are

(A) reduce, where necessary, each payment to terms of the original data i.e.

 $cost = 4,000 + 5,250 \times \frac{96}{105} + 15,000 \times \frac{96}{150}$ = 4,000 + 4,800 + 9,600 = 18,400

retention = $\pounds 10,000 \times \frac{24,250}{18,400} = \frac{\pounds 13,179}{18,400}$ Reinsurer pays $\pounds 11,071$

(B) adjust the indexed payments as at the final date i.e.

$$(5,250 + 15,000) \frac{96}{150} = \pounds 12,960$$

retention = £10,000 x $\frac{20,250}{12,960}$ = £15,625 Reinsurer pays £8,625

(C) unindexed retention = $10,000 \times 4,000 = £1,650$ 24,250indexed retention = $15,625 \times 20,250 = £13,048$ 24,25014,698

retention = £14,698 Reinsurer pays £9,552

In our view A is both straightforward, sensible and easily understood. It follows the concept of measurement in real terms by expressing every payment in terms of the money of the date of the reinsurance contract; recoveries can be treated without difficulty be applying them, rateably if necessary, to the payment which has been partially or wholly recovered.

Note that when a "10% clause" applies (that is the index clause comes into operation only if the index has risen by at least 10%) the payment of £5,250 could be treated as either £5,250 or £4,800 according to ones interpretation of the clause, namely that it applies if, and only if, the index has risen by 10% by the date of final payment. However, this gives the direct writer a strong incentive to delay a small final payment should the index not have

risch quite enough when he makes the normal final payment. On the other hand if the 10% applies to each payment separately there might be an incentive to defer payment for a few days if the index is, say only 9% up. It would seem to us a needless refinement to introduce the 10% clause since the opportunities for adverse selection, with resultant ill feeling, far outweigh any benefits it may have.

9.6. DIFFICULTIES WITH AND DESIRABILITY OF INDEX CLAUSES

A direct writer may be unhappy over the operation of an index clause on the grounds that he no longer knows what cover he is buying. The answer is "true", but this is by no means his main uncertainty. Let us consider a motor portfolio of 100,000 comprehensive vehicles with an average premium net of NCD of £30 covered for the whole of the year 1972, with a single excess of loss treaty with a lower limit of £25,000 and no upper limit. Then on the assumption of a steady 5% inflation and no interest or underwriting profit the allocation of the premium of £3,000,000 might have been roughly, in £000;

Commission	450
Initial expenses	150
Claim settlement expenses	400
Claims under £25,000	1,850
Reinsurance premium	150
	3,000

The reinsurance premium may be assumed, for our purposes, to cover the larger claims with no allowance for commission interest or expenses. If inflation is that experienced since 1972 the actual outgo would have approximated to;

Commission	450
Initial expenses	150
Claim settlement expenses	450
Claims under £25,000	2,050
Reinsurance premium	150
	3,250
Premium	3,000
Taga	
Loss	! 250
$= 8\frac{1}{5}$ %	
Reinsurer Claims	300

Reinsurer	Claims	300
(at	least)	
Premium		150
Loss		150

= 100%

If an index clause had been in operation the total claims cost of 2,050 + 300 = 2,350 would have been shared in the proportion 1850/150 that is the direct insurers claim cost would have been 2,174 and the reinsurers 176, so that the direct writers loss would have been 12^{1} % and the reinsurers 17% of their respective premiums.

Put another way the direct insurer would need to recoup his loss of 374 out of next years premiums of, say 3,500 and the reinsurer his loss of 26 out of next years premiums of, say 400. Without an index clause the reinsurer would have had to recoup 150 which would have required a very large premium increase.

The uncertainty for the direct insurer stems mainly from the increase in liability on the claims below the excess of loss level, from escalating expenses and, from time to time, investment losses, and the extra uncertainty he is required to shoulder under an index-linked reinsurance contract scems reasonable.

It must be remembered that in the long run losses incurred by the charging of inadequate premiums will fall on future policyholders, irrespective of the way in which the premium and liabilities are currently shared between direct insurer and reinsurer and that a stable market can exist only if unforeseen and unforseeable losses can be recouped. If one wants an insurance and reinsurance market one needs the insurers and reinsurers to continue in existence and to remain solvent when the claim ultimately comes to be paid, and for most insured the larger the claim the more vital it is to have cover and to know that the claim will be met however long it takes to settle.

9.7 EXTERNAL FACTORS OTHER THAN WAGE INFLATION

An index clause in excess covers does not necessarily maintain the relative positions of the cedant and reinsurer throughout the period of the cover. An index clause based upon wage levels maintains the ratio of reinsured liabilities to retained liabilities in terms of wages for those claims covered by the treaty at the level which would have applied had the claims been settled at the date of the treaty. It makes no allowance for other external factors. Figures show that personal injury claims have over a period of years tended to escalate at a higher rate than any of the inflation indices currently available due to the influence of higher awards in the Courts. Other secular changes such as those listed in 2.9 above may affect the frequency and amount of claims though generally to a lesser extent.

Any upward change in the legal basis for compensation may disproportionately affect the reinsurer since such changes are likely to be retrospective in that all future awards for personalinjury will be increased, including those in respect of claims incurred before the date of introduction of the new basis. This applies to the bases affecting both liability and quantum and the introduction of indexed annuities or damages on a no fault basis may also have implications here.

9.8 INDEXED ANNUITIES

In sharing the increased cost resulting from inflation the aim should be to express all payments in the same relative monetary terms as applied at the date of the treaty. Whilst not a particular problem where lump sum awards are concerned, the introduction of periodic payments for personal injury claims linked to a cost of living index, as in France, is more complicated where excess of loss reinsurance is used. One approach would be to adjust each payment to constant monetary values so that when such accumulated payments reach the excess point the reinsurer is liable for any excess, re-expressed in the monetary values at the date of payment. The alternative would be to value an annuity on an agreed basis and treat it in the same way as a lump sum payment. A lot depends upon the arrangements set up to deal with such awards. For example, in France inflationary increases are met out of a central fund supported by a levy on current policyholders, which could have the effect of transferring some of the burden of inflation between different generations of policyholders. Changes in SOcial standards can substantially alter the nature of the risk and although any changes in law are unlikely to reduce the aggregate amount of damages awarded to all claimants they do not necessarily result in undesirable risks provided that they operate in a relatively steady and predictable manner.

This subject was considered in more detail in GIRO 6; it may well require more extended treatment when the Pearson Commission has reported.

10 REINSURANCE PLANNING

10.0 INTRODUCTION

It was originally settled that this paper should be a joint effort by two working parties, one of which would deal with technical matters, and the thoughts of this party are contained in Sections 1 - 9. The other working party was to consider management of the reinsurance of a direct portfolio and the retrocession of a reinsurance portfolio as well as the writing of reinsurance business. Unfortunately, however, the latter working party failed to make much progress and the Chairman of the first working party was asked to take over. He found that four of the members had begun to write notes or to work on a mathematical model based on some Italian data. It is hoped that a note on that model will be available for circulation before the York meeting. In view of the shortness of time however and the fact that what had already been written overlapped the earlier sections (it is a comforting thought that there was no serious divergence of view), the Chairman of the first working party decided, and the members of the second party agreed, that he should edit or re-write or add to what the latter had done in order to fill in the references made in the earlier section.

It is not suggested that there is anything particularly novel in what follows, although an attempt has been made to go back to first principles and rationalise what reinsurance aims to achieve in an irrational world, with the intention of relating practice to some sort of theoretical model. It must be realised that this is not a precise subject; it is based on hunch, prejudice, habit, inadequate information both on current risks and the outcome of recent years business, and, as so often happens in those areas of direct insurance where rating is difficult, it may well pay to conform to market practice even when it is absurd, rather than to go it alone.

What follows is really a certain amount of thinking aloud with the intention of providing a basis for discussion at York.

10.1 THE REASONS FOR REINSURING

We have in the earlier sections of this paper considered the practice of reinsurance, especially in the United Kingdom, and outlined some of the theoretical background. Without some technical knowledge the actuary cannot have a sound basis for exercising judgement; experience, market practice and commercial and administrative considerations are, and are likely to remain, of dominant importance, at least until the profession has gained much wider experience and, to some extent, so long as economic conditions are not sufficiently stable to permit accurate forecasting.

It is well known, in direct insurance, that risk classification into more and more homogeneous groups is important in leading to correct risk premiums and to the avoidance of selection against an insurer. There must however be a limit to this process of sub-division, since in the limit each risk will pay for its own claim cost and expenses. The situation in reinsurance is in some ways similar in that an insurer usually wishes to spread some of his risk around the market by reinsurance. Spreading arrangements are in practice extensive and the ultimate would seem to be a single insurance pool which received all premiums and paid all claims; this is the logical opposite to the ultimate sub-division of risks in direct insurance and is equally absurd. The practical problems are how far the process should be carried, and how the actuary can help in formulating principles.

We have referred in Section 1 to the various types of insurance available. We next consider the nature of the risks against which an insurer requires protection. Let us first consider the case of an office writing one class of business, in one country, and which can be regarded as roughly homogeneous at least in the nature, but not necessarily the size, of risk, and let us assume that the correct risk premium for every risk is reliably known, as is the risk premium for any band of claims in excess of any specified amount. It is a totally impractical concept, but it is a useful starting point for logical analysis, and the effect of introducing various degrees of uncertainty can be studied subsequently.

10.2 THE VARIANCE OF CLAIMS COSTS

If the claim frequency is known to be p claims per year per risk, and if the mean and variance of the distribution of claim amount are μ_{0}, π^{*} then the number of claims can be regarded as a binomial distribution so that on N risks the mean (expected) number of claims is Np and its variance is Np(l-p) (p is normally small enough to enable us to use Np) and the variance of total claim amount is Np((l-p) $\mu^{2} \neq \pi^{*}$).

If we apply normal theory then the probability that the claims will exceed the technical reserves (which we have postulated to be Np) by more than the solvency margin S will be less than .001 if

If the left hand side is too big we can reduce it in three ways

Reduce N, that is write less business
Reduce N, that is retain less of every risk or less of
some risks
Reduce N, that is, in effect, reduce the upper limit
of loss.

It should be noticed that in many forms of property

and liability insurance the bulk of the contribution to 9° arises from just one or two very large claims; see the paper on motor data base presented to the Windermere Seminar.

10.3 THE PRACTICAL REDUCTION OF VARIANCE

If the direct writer needs to pass on some of the risk he has accepted then he will have to pay a reinsurer to accept it. If both parties have the information postulated above then the premium asked by the reinsurer will comprise two components

1. A risk premium

2. A contribution to his expenses and profit. In practice there will be a third item

3. A contribution towards the solvency margin of the reinsurer or a fluctuation loading

although in many years, especially in the 1960's item 3 was eventually found to be both negative and

large. So long as 2 + 3 is positive the direct insurer reduces his profit by reinsuring, and his aim must be to code such part of his risk as reduces his s.d. to less than one third of his solvency margin consistent with the smallest value of the corresponding total 2 + 3. If 2 + 3 is consistently negative the reinsurer will either raise his rates or go out of business or both.

If the reinsurer was accepting risks only from the one direct writer, the problem would, most likely, not have any solution other than the availability of the additional capital of the reinsurer to support a larger solvency margin. In practice, however, the reinsurer will be accepting similar risks from many cedants so that his total variance, at least from random variation, will be relatively smaller than the variances individually ceded to him; this is merely another way of expressing the fundamentals of risk sharing.

There may in practice be a further constraint on the direct insurer, namely that he may be restricted in the premium he retains to a multiple of his reserves or capital. At this point the logic of such a constraint is not easy to see, unless the contribution of γ^{-1} to the variance is small, which is probably untrue for much of a portfolio.

10.4 INDEPENDENCE OF CLAIMS

So far we have assumed that with the overall claim frequency p all events are independent. In some classes of insurance this may be nearly enough true to be acceptable, but in other classes, at least considered in isolation, the risk of several claims arising from one event can be serious. Examples are:

an aircraft accident where all passengers are covered by a single policy, a common practice in the package tour world (similar risks could arise with bus or train accidents, but they are much less likely to involve multiple claims on a single policy or group of policies, except for the very rare occasions when a road vehicle derails a train)

a hail storm where crops or glass-houses are involved

a windstorm

an earthquake

In such cases the expression for the variance of the mean total claims, calculated on the assumption of independence, can be very wide of the true value, and the need for catastrophe excess of loss or stop loss insurance may arise.

10.5 THE PRACTICAL SITUATION - EXCESS OF LOSS COVERS

The state of affairs we have so far postulated in this Section is quite unreal and likely to remain so for a very long time. It ought not however to be dismissed since our decisions must be made with the ideal position in mind.

The first thing to remember is that when a direct writer cedes . business; he is parting with some risk and some premium. If the reinsurer is guoting properly, the premium given up will exceed the expected value of the claims passed on, with a net loss in the long run to the direct writer, representing the economic cost of reducing his variance and, therefore, his risk of ruin.

The decision as to what risks can be taken depends on the philosophy of the management, the utility they attach to the retention of premium and the need to offer business on a reciprocal basis. In current conditions many of these decisions have to be taken with totally inadequate information, especially in

relation to the higher excess or stop loss points. How, for example, can a direct writer assess the premium asked for cover of an Employer's Liability account for the unlimited excess of £250,000 any one accident indexed on an earnings index when the highest two claims he has had in the last thirty years, also indexed up to the present day, are £50,000 and £75,000 of which the larger still remains unsettled? Curve fitting won't help him and we must beware of thinking we can do better than a non-actuary.

Would anyone say that £50,000 a year was right? If it related to a premium income of £10,000,000 we could regard it as the price of peace of mind; but what if the premium were £1,000,000 or even £500,000?

Some calculations were performed by Johnson and Hey on one large portfolio. They have been brought up to date recently and can be used to form an estimated reinsurance premium for an indexed limit of £50,000 in 1976 with a modest degree of confidence (that is within a factor of perhaps 2 either way!) but at £100,000 the margin of error is much larger and these figures are based on over 10,000,000 vehicle years / exposure. One reinsurer collected some figures in respect of the treaties it underwrote and published them some time before the very high inflation rates began; they did not indicate the number of vehicle years covered, but the amounts of original gross premium income suggested that they could have been in the 10 - 20,000,000 region over the period involved. The data were analysed gross, not in real terms, and the margins of uncertainty seemed to be comparable to those above.

The direct writer's course of action would seem to be to get two or more quotations for each of three or more levels or bands of excess of loss cover; if two quotations for a given cover do not differ by much, the merits of continuity of reinsurer will probably decide the issue. The differences between premium for different levels will be decided on a rough and ready appraisal of the amount of liability given up for each increase in premium and the consequent increase of the risk of abnormal fluctuation.

10.6 THE PRACTICAL SITUATION - CATASTROPHE EXCESS OF LOSS

The position here is even more difficult on both sides. Estimates have been collected of total storm damage by the occasional violent storms in recent years in the United Kingdom. It is only in about one year in three that storms of such violence merit investigation and only every second or third of these give rise to any really serious fluctuations in claim amount. All the direct insurer can do is to make some very crude calculations on the assumption of a loss every five years or so, but of an amount that he finds very difficult to assess. An appropriate point for the excess level would seem to be the sort of fluctuation from year to year that he could contemplate with equanimity at a premium that did not represent too large (say ¹/₂% to 2%) a share of his total premium income.

10.7 THE PRACTICAL PROBLEM - PROPORTIONAL REINSURANCE

So far as random variation is concerned proportional reinsurance is an inefficient way of reducing variance, at least on the basis of correct risk premiums, since it passes on a large number of small claims, which add little to the variance, in the process of getting rid of the big ones that cause most of the variation. In doing so it may well pass to the reinsurer more premium, and, at least in theory, more profit than is necessary in regard to the fluctuations arising from a few large claims. The qualification in the first seven words of this paragraph are however all important, since, at the present time, other sources of fluctuation in claim amount often predominate and the case for proportional reinsurance becomes stronger.

10.8 NON-RANDOM VARIATION

We have in Sections 10.2 to 10.7 been concerned solely with the reduction of random variation within a stable claim situation, with a known and constant claim frequency and a known and constant distribution of claim size with all the details known to both parties. This is an area which has been examined in great depth theoretically, often because the writers of the papers have had little or no factual information available. This situation was never realistic even in more stable times, but during the 1960's and 1970's the fluctuations arising from other sources, primarily inflation, but also to a significant degree the external factors we have already considered tended to predominate. In these other cases the degree of fluctuation will depend on the type of business, especially the proportion that represents liability for bodily injury, professional negligence, or public liability, but otherwise the variation in total claims will be proportional to the mean rather than the variance. In such circumstances propertional reinsurance may well be an efficient way of reducing overall variation in results, and the main other risk to be covered by reinsurance may be the risk of associated claims requiring stop loss cover.

It must be realised that stop loss, where the cover relates to an aggregation of claims from a single event, (storm, explosion, aircraft crash) is a reasonable concept since in most cases the expected claims under the treaty are likely to move in proportion to the total premiums (or claims). A stop loss relating to the total claims over a year if in excess of some percentage of total premium seems on the face of it a potential nonsense in current circumstances since it throws the whole burden of inflation, in excess of some level implicit in the percentage chosen, on to the reinsurer, or alternatively if inflation is less than that level may give him the whole or a large share of the benefit. As we have said in regard to excess of loss this can result in an unfair, but certainly unpredictable, sharing of the inflation risk.

10.9 STATUTORY AND OTHER LIMITATIONS

A super visory authority usually imposes some limit on the amount of net premium that may be written in one year in terms of the solvency margin (S) shown in the accounts at the end of the year. In the United Kingdom this limit, except for the smallest companies, is not much under 10 S, but under E.E.C. rules it will be reduced to about 5S. Lloyd's requires a limit of lOC where C is the admissible capital deposited; they ignore any surplus in the underwriting accounts, even though this could be substantial.

It will be seen, in view of the remarks above, that this is a most unscientific basis. In the first place it virtually ignores that part of the risk that arises from random variation, where the solvency margin should be related to \mathfrak{F} rather than \mathfrak{p}_{-} . It also ignores the nature of the business since a multiple that is adequate for a property insurer will probably be totally inadequate for a liability account, and both will be quite inadequate for an excess of loss reinsurance specialist especially if he is writing the higher layers.

It will be seen that these limits can be restrictive, especially where the basis is N.S since S is liable to violent fluctuation and is unknown until well after the premium has been written, and most insurers in fact aim at a limit of not more than 3S.

Reinsurance, or retrocession, will be essential whenever the written premium threatens to exceed the statutory limits and we now require the most efficient way of reducing net retained premium; this will normally be the quota share or surplus treaty arrangement, the choice depending on the nature and number of the risks written.

One advantage of a/treaty is that it can be used selectively to pass on a share of the large risks and in doing so serve the joint purpose of reducing variance (often substantially) and also the net retained premium with a good deal of flexibility subject to the need to balance the premium ceded in relation to the maximum risk passed on. The reinsurer will normally require, quite rightly, some sort of balance between the premium he receives and his maximum potential loss on any one risk; perhaps 1 : 1 for a first surplus treaty to as much as 1 : 4 for a second or third surplus treaty where he will rebate less commission in order to give himself a larger contingency loading. This brings us to P.M.L. and E.M.L. which we consider in the next Section.

10.10 PERCENTAGE LOSS

Records show that for many forms of property insurance total losses are quite rare, and a large proportion of claim costs arises from partial losses. A direct writer ceding part of a large risk is therefore seeking protection from fluctuations that he may not need (unless he is trying to reduce his net retained premium as explained in 10.9). He may feel that although the total sum insured is more than he would normally retain, the chances of a total loss are so remote, or seemingly impossible, that he would be willing to retain the whole, or an abnormally large amount for his own account.

For example he may cover a parade of twenty shops and upper parts built in four blocks of five shops or even in a single terrace of twenty. With normal construction the chances of more than one being totally destroyed with perhaps some damage to the two adjoining units, are so remote that he may consider his maximum possible loss as equal to two units. This concept has been greatly elaborated by insurers anxious to retain the highest proportion of their written premium using various names such as:

Probable maximum loss (PML) Maximum probable loss (MPL) Estimated (or expected) maximum loss (EML) With the alternative of possible for probable.

The use of the English language by the reinsurance market is odd; one suspects that they think possible means the same as probable and, for once, they avoid anticipated on one of the rare occasions when that word would, or at least might be right and where expected is almost certainly wrong! However, the reader will no doubt understand the aim, namely that they are seeking to assess the amount that no claim is likely to exceed.

Obviously it requires technical judgment to arrive at a PML with a good deal of information regarding the construction, fire fighting equipment, the possibility of a violent explosion, the failure of safety devices and "fire-proof" barriers, and the final result can be no more than an informed guess: very different figures can be reached by different underwriters. Even with cautious assessment there is always the risk of the unexpected such as:

The delayed arrival of the fire brigade Delayed detection Abnormal storms Failure of sprinklers or water supply Violent explosion The experience at Flixborough no doubt gave rise to losses in some cases far in excess of the PML's and this could have applied also to properties such as a row of shops or houses some distance away (note that in such cases there could well be a claim in respect of the explosion if some party had been negligent and he,or his insurers, were capable of making restitution).

Particular problems arise in the case of large blocks of property, such as a factory or a tower block, and estimates of PML in such cases seem to be based at times on a very flimsy basis. On the other hand in the case of a group of adjacent buildings, say a series of separate factory buildings, a single PML may be totally inappropriate if the values of the individual buildings are very different from one another.

Where retentions and cedings on a surplus treaty are based on a PML rather than a sum insured it is clear that the reinsurer may be faced with a very large claim should the assessment prove to be incautious, and some form of excess of loss cover is desirable, provided it can be obtained at a reasonable premium.

To sum up it seems that despite the theoretical and practical advantages of appraising risks, less by value but mainly by their damage potential, experience has proved repeatedly that, in practice, EML or PML estimates suffer from serious defects:

- They are often based on an appreciation of a risk under normal operating conditions and may not take into account emergency situations or special circumstances likely to arise prior to, or in conjunction with, a large loss.
- (ii) They may be prone to optimistic assessment, particularly in respect of new industrial processes, the hazards of which have not had time to materialize, of which Flixborough was a spectacular example.
- (iii) They are exposed to psychological pressure, particularly when the risk is large or the placing is difficult.

Errors in such estimates of up to 150% of the EML assessment are by no means unkown. In extreme cases losses have reached 100% of a total sum insured whilst the EML estimate was only a small percentage of it.

It is important not to underestimate the varied skills, knowledge and experience needed to accomplish a proper EML evaluation. An EML, however carefully estimated, can always go wrong, with serious consequences for the underwriter, unless special reinsurance protection is obtained. In such circumstances, the reinsurer will require to be informed of the Company's particular approach to its EML assessments.

10.11 GOOD RISKS AND BAD RISKS

When we consider the choice of risks to be placed on a treaty and the levels of retention by a direct insurer we referred to the danger of adverse selection. It is common to refer to a risk as being good if the probability of a major claim is considered to be smaller, or much smaller, than "average". This is however a perverse use of the word good, since on the whole, the important factor is whether the premium is adequate for the risk. If the premiums are fully adequate for the risk, then clearly the more we have the better: if the premiums are not adequate we should not go on risk at all. Rating, however, is not an exact science, and major claims are quite rare so that the instinct to give cover on, say, an office block, for large amounts is understandable in human terms (it probably will not happen anyway!) but is clearly illogical. If we obtain only a small risk premium (say 1 per 1000) then if a total loss does occur, it takes a very large number of other premiums to pay for it, whereas if the premium is 20 per 1000 it takes far fewer. So long as the risk premium is correct, one should retain less of the good (low frequency) risk, and more of the bad (or high frequency)! It seems very hard to get underwriters to accept this logic, although it is identical with that involved in deciding on the balance of the treaty - that is the relation between total premium and maximum risk per event, which they seem to understand very well.

10.12 THE RELATION BETWEEN CLASSES AND COUNTRIES

So far as the solvency and annual results of an insurer are concerned it is necessary to consider reinsurance only in the context of the entire world-wide portfolio, except to the extent that there may need to be different treatment of overseas business where there is a currency risk as well as, often, the requirements of the Supervisory Authority abroad in regard to business solely within its country. If a company can stand a chance of loss of £x in class A, then it can equally well stand it in class B and similarly with regard to accumulations of risk. (In the latter case however it is only in a few classes where accumulations are liable to be a problem).

However if a company wishes to judge its departments, or branches, or agents fairly between each other it may well need some external or internal

rearrangement for each class, branch or agent; especially the smaller ones. If an agent has 1,000 motor policies at a total premium of £40,000 then a single claim of £100,000 would make his results, even over ten years, look very adverse, probably without justification. The fair way to judge in these cases is to treat each group as an entity, charge it a reinsurance premium and ignore claims, or a concentration of claims, exceeding some limit which may well be quite small: perhaps 5% of written premiums. These amounts are credited and debited to an internal reinsurance fund, through which could also pass premiums and recoveries in respect of external reinsurance.

To use external reinsurance for small classes is liable to be expensive and to strain further the capacity of the reinsurance market.

10.13 RECIPROCITY

It seems that technical judgements can be influenced by reciprocity. That is A will undertake to cede certain business to B if and only if B will cede "comparable" business to A. If, as seems to be the case, there is a large amount of business placed within a group of insurers on this basis it is tantamount to a form of risk spreading, but it will be fair in general only if the various companies write business on comparable bases and do not select unduly in their cedings. Another case of the utmost good faith.

10. 14 COINSURANCE

This is a form of risk sharing that is akin to quota share insurance, except that it normally applies only to large risks and is arranged on an individual basis, at least in theory. If there are three companies A, B and C writing similar amounts of business then the effect of each taking one third of every risk (coinsurance) is exactly the same in practice (but not in law) as if each writes one risk in three and cedes one third of all its business on a quota share treaty to each of the other two.

In practice in coinsurance one insurer, usually a large one, will assess and rate the risk and take the largest <u>individual</u> share. Other companies will accept the risk on the same basis but for a smaller proportion than the leading insurer. The details will be arranged by the broker placing the risk, exactly as he would do with a Lloyd's syndicate. In theory there is no limitation on the participating companies and the size of their shares, but when both members and non-members of the FOC are on the same risk some restrictions are normally imposed on the total share of non-members. Coinsurance is identical in form and in practice (but again not in law) with facultative proportional reinsurance.

10.15 MARINE & AVIATION

This market is a law unto itself, and we do not dare venture into/it. Probably more than any other form, either of direct insurance or reinsurance, it works to its own rules and customs. If one criticises it as being irrational and illogical it can retort that after 400 years it is still in business and flourishing, which is quite a good record. There will one day be scope for more scientific investigation, but there are other more urgent areas, for example liability covers.

10.16 CONCLUSION

It is not suggested that there is anything novel in the factual information in this section, but it is hoped that it has been written in such a way as to give the non-expert a picture of the theory underlying the practice. What actuaries must do is to concentrate on those areas in which their technical knowledge or judgement can be brough in, in order to give guidance on the extent to which reinsurance is desirable and to assess, so far as is practicable, the value offered by a reinsurer. The section has given little that is relevant to the conduct of a reinsurance business. Indeed, one may well ask how a reinsurer may conduct his business rationally: the answer is partly that he cannot, but so long as the market moves roughly together then, since we shall still require reinsurers for as far ahead as we can see, they will be available only if direct writers generally are prepared to pay premiums in future to recoup past losses.

It may not be scientific, it may not be logical, it is certainly not wholly fair, but it has worked for a long time. If it were not so, one suspects that the events of the late 1960's and the high inflation of the early 1970's would have had disastrous results! The actuarial profession needs to learn much and to proceed warily until it has more understanding than it does at present of this complex subject, with its serious shortage of reliable statistical investigation.

SPECIMEN INDEX CLAUSE

- (a) It is the intention of this Agreement that for Liability claims in respect of Personal Injuries only the retention of the Company and the maximum liability of the Reinsurer as set out in this Agreement shall retain their relative monetary values which exist at 1 January 1976.
- (b) At the time of payment of any claim the change in relative monetary value shall be measured by using the latest available index for wages in respect of Manufacturing Industries contained in the Monthly Digest of Statistics published by Her Majesty's Stationery Office, London.
- (c) If at the time of payment of any claim in respect of personal injury the index figure then applicable shall show a variation of more than low from the figure at the 1 January 1976 then the retention of the Company and the maximum liability of the Reinsuver shall increase or decrease as the case may be in proportion to the increase or decrease in the index from the 1 January 1976 to the time of payment of the claim.
- (d) The time of payment of any claim for the purpose of this Agreement shall be deemed to be as follows:
 - i) Where no award is made by the Courts the actual date upon which payment is made by the Company.
 - ii) The date an award is made by a Court (if no appeal is made or if the Company appeals).
 - iii) The date an award is made by the Appeal Court if the case is taken to Appeal by a party other than the Company.
 - iv) In the event of a loss being settled in more than one payment, notwithstanding anything to the contrary contained in subparagraph i), ii) and iii) above, any advance payment in respect of any claimant shall be added to the final or any subsequent payment to the above mentioned claimant and the index used at the time of the final payment shall be the one employed to ascertain the retention of the Company (and the maximum liability of the Reinsurer) in respect of all payments to the above mentioned claimant.
 - v) Payments for expenses incidental to the investigation of claims shall not be taken into account when calculating the retention of the Company.
- (e) The Company has the right to request the above conditions shall not apply or shall only partially apply if proof can be furnished that
 - i) the payment of any claim was based on relative monetary values prevailing at a date prior to the actual payment, or
 - ii) the variation in the index has no bearing on a specific claim, or
 - iii) the application of the clause is inequitable to the Company

it being the intention always that the conditions of paragraph (a) of this article shall be fulfilled. The Company and the Reinsurer shall arrive at a fair decision on such a matter but in the event of disagreement the matter shall be referred to arbitration as herein provided for.

Bibliography of publications dealing with non-life reinsurance

The aim of this bibliography is to go back about ten years on topics contral to reinsurance, but to go back about half that period on specialized topics on the fringe of reinsurance where published papers themselves give earlier references to enable a particular topic to be followed to earlier years.

Items have been elassified under their primary subject. Other topics are mentioned in the comments and these should be scanned for items of possible interest.

The following abbreviations have been used :-

ARCH	Actusrial Research Clearing House
ASTIN	Actuarial Studies in Non-Life insurance
BAF	Bulletin de l'Institut des Actuaires Francais
CAS	Casuality Actuarial Seciety
CII	Chartered Insurence Institute Journal
JII of L	Journal of the Insurance Institute of London
JSS	Journal of the Institute of Actualies Students Society
ROA	Reinsprace Offices Association
SIGMA	Swiss Reinsurence Congeny
SK AKT	Skandinavisk Aktuarietiäskriit
TICA	Transactions of the International Congress of Actuaries
TIRANZ	John and the first of the very been of another a construction of the second states of the

CONTENTS:

la 1b	Bibliographies (see also text books) and revisitistics Text books on reinsurance practice and on risk theory
2A	Descriptive and non-statistical papers
23	Supervision of reinsurers
3A	Sources of uncertainty and fluctuation
3B	Indexing and offects of inflation
4A	Rate-making-more practical.
4B	Rate-making-more theoretical
5 6	Retention levels, Hill and Rill
6	Distributions of large claims
7	Co-insurance - practical application or modelling
8	Optimal reinsurance and utility wheory
9	Solvency and ruin probability
10	Fire data

1A Bibliographies and raw statistics

B

	CII LIBRARY	Biblicgraphy on reinsurance - pp.9 "Thorough list of short articles - non-mathematical"			
	COCKERELL H	Legal reviews. The Review (monthly)			
	CII	Index topports in previous volumes CII 72 and 53			
	JII of L	Index to papers in previous volumes JII of L 53			
	SIGMA	Natural catastrophes and major losses - annually "By date, location, cause and victims or damage"			
1975	LE FRIL N & D'HOCCE & GCOVAENT	Bibliography on credibility theory and S applications J Comp Applied Maths			
1972	BAVARIAN REINSURAN	CE CO International bibliography (looselear) "Very complete (to 1972) on short descriptive articles from Review, Reinsurance, Policy etc and technical refs."			
Text	books on reincurane	e practice and on risk theory			
	CII	Study Course IC 102 "Methods and categories described" pp.250			
1970	BUHIMANN H	Mathematical methods in risk theory. SPRINGER-VEELAG			
1969	BEARD R E & PENTIKAINEN & PESO	Risk theory. METHUEN NEN "especially rate making, coinsurance and bibliography"			
1969	SEAL H L	Stochastic theory of a risk business WILEY "especially rate making, retention, utility theory and very extensive bibliography"			
1968	GOLDING C E	Law and practice (4th Edition) Buckley Press London pp.189 "Chapters on facultative, treaty and excess of loss"			
1966	THOMPSON K R	Reinsurance - practice and legal treatise USA pp.560			
1960?	• ТОМА Ј	Administration of professional reinsurance Bombay pp.113 "Organisation and methods - statistics and account keeping"			
1 955	VAJDA S	Non-proportional reinsurance ARITHBEL pp.171 "Types of contract, history, rating and fluctuations"			
1954	LANGLER W J	The business of reinsurance USA pp.465 "Practical dotail with wording of specimon agreements"			

2A Descriptive and non-statistical papers

2B

1975	II of L	Excess of loss methods. Group Report 201			
1974	PEARCE E A	Excess of loss: review of standard clauses (fird and allied parils) Canadian Int Ins Brokers pp.36			
1.974	CAMEY D	Excess of loss and the computer. The Neview 1/ 2/74 "Long tail, need for IENR expenses, investment income"			
1974	NEAVE JAS	Handling of large risks. The Review 1/2/74 "How reinsurance is coping with increasing size of risks - both property and liability: searcity of expertise in and information for risk assessment"			
1972	MOMACHOS A R	Reinsurance in Facilish private international law Journal of Business Law July 1972			
1971	FOX D	Recent developments - avlation and marine. Review 5/ 2/71			
1970	EROMLEY R J	Marine excess of loss II of L (lecture)			
1969	MEAVE JAS	Reinsurance in the seventies JNI of L 58, 66 "problems and prospectus in the next ten years"			
1968	NEAVE JAS	Role of the professional reinsurer CII 65, 81. "provide sound and continuing cover on a long term basis"			
1966	unistan d f	Reinsurance in the modern insurance world. JII of L 55, 15 "complexities of reinsurance operations today"			
1966	HANDOVER R A	London non-marine reinsurance market CII 64, 121			
1965	NEAVE JAS	Reinsurance today - a general survey CII 63, 47 "current methods and procedures in practice"			
1964	GROSSMAN M & KOENI	G Insurance markets of the world. Swiss Re			
Super	vision of Reinsurer:				
1976	Dyff: A W	General Insurance Reserves and Security in an inflationary cra. II of L Address given 2/2/76			
1974	ABEOTT W M (ct al)	Technical Reserves and Statutory Returns in General Insurance JIA 101, 217 "Requirements and completion of UK returns summarised with a little mention of reinsurance"			
1972	HEARD R E	in Supervision of Insurance in UK - a discussion JIA 98, 240 "Supervision method within Lloyds"			
1971	SIGMA	International comparison of cartel legislation and its application to insurance STGMA February 1971			
1963	HURREN, H G	The official supervision of insurance companies CII 61, 133 "one page on reassurances given off"			

3A Sources of uncertainty and fluctuation

1976	ROBERTSON A	US nuclear incurers most explosive growth Policyholder 11 June p.1056 "reserve fund 44M, liability limit 125M, 27 incidents"
1976	ROA	Earthquakes - a general introduction
1975	UNDER 35 REINSURANCE GROUP	America 1975 report "Current problems - windstorm, earthquake, riot and Casualty"
1975	ROA	2nd International seminar University of Sussex "effocts of catastrophic losses on markets"
1972	FRIEDMAN D G	Insurance and the natural hazards ASTIN VII 4 "risk evaluation, forecasting and simulation, examples from flood, earthquake, wind"
1972	CRESSWEIL J N	Catastrophes JII of L 61, 17 "descriptive outline - mainly USA"
1972	JOHNSON P D & HEY G.B.	Fluetuations and secular changes in claim costs TICA 19 II 653
1972	SOUSSELLER J	Formes de substitution a la reassurance traditionelle TICA 19 II 691 "difficulties of the modern world lead to new methods"
1972	VISCHER H B	Reinsurance - large and new risks CII/AIMIC Nottingham pp.16
1971	ROA	Discussions on delays in advisingelaims Reinsurance 2, 193
1968	RAMEL M	Sources of uncertainty when quoting for excess of loss agreements (in French) TICA 1811 621 "includes experience data"
		inflation

3B Indexing and effects of inflation

1975 GUASCHI F E Accident excess of loss: recent effects of inflation. The Review 11/ 4/75 "supported by figures on claim size and delay"

1974 N R G QUARTERLY Stability clauses in excess of loss reinsurance LETTER August 1974

1968 FOSTER G T Accident Excess of Loss "rating and outstanding claims" M & G

1964 BENKTANDER G New forms of excess of loss reinsurance TICA 17 III 50 "explains the EPNOC treaty"

4A

4B

Rate	making-more practi	cal
1972	WETZEL LAPARRA SENECHAL	Cotation des excess par un graphe universel "use of log log graph paper to rate catastrophes" BAF 71, 337
1972	FERCUSON R E	Allocating premium to layer by the use of increased limits tables CAS 59, 43 "excess of loss for passenger automobile bodily injury"
1972	BENKTANDER G	Claims frequency and risks premium rate as a function of size of risk ASTIN VII, 119 "practical problems and an analytic attack, translation, 25 refs"
1972	SIMON L J	Actuarial applications in catastrophe reinsurance CAS 59, 196 "logical consistency (equity) among various alternative contract terms, illustrations"
1971	FOSTER G T, FOWLER, HARDING KHURY and LANDIN	IBNR (and liability excess of loss). NRG pp.132 "Prize papers dealing with theory and practice"
1970	CATLEY D	Accident Excess of Loss - combined statistics as a guide M & G
1969	GUASCHI F E	Accident Excess of Loss - an actuarial approach H & G
1968	HARDING V	Calculation for excess of loss for motor reinsurance TICA 18II 445
1968	GUASCHI F E	Non-proportional reinsurance JSS 19, 55 "life and non-life - practical problems of rates"
1965	HARDING V	Non-life insurance and the statistician JSS 17, 459 "application to excess of loss - theory and practice"
1955?	TUMA J	Stop Loss Cover, Paul Loosli, Geneva pp.103 "Graphical methods numerical examples, Richard and Luftfalla treaties"
1954	BEARD R E	Statistical aspects of non-life insurance JSS XIII, 13 "mentions the ECOMOR treaty and its basis"
Rate n	aking - more theor	etical
1975	BENKTANDER G	Calculation of fluctuation loading for excess of loss ASTIN VIII, 272
1974	BENCKERT L & JUNG	Statistical models of claim distributions in fire insurance ASTIN VII, 1 "includes determination of excess of loss premiums"
1974	ROBERTSON R S	Reinsurance - a practical application of credibility theory. Actuarial Research Conference Berkeley 19/ 9/74 ACADEMIC PRESS "20 references to credibility"

1972 McFALL M C Net Stop-loss premiums ARCH 1972.3 "references to other American work"

Analysis of claims experience in motor excess of 1972 VERBEEK H G loss ASTIN VI 195 "Rating and IBNR costs - a model for forecasting"

Credibility for loss ratios (translation) ARCH 1972.2 1970 BUHLMANN H

5 Retention levels, FAL and PAL

1975 ROA EML - ROA definition. The Review 11/4/75

1975 RAMACHANDRAN GFactors affecting fire loss ASTIN VIII 229
"model with multiple regression developed and applied"1969 McGUINNESS JIs PML a useful concept? CAS 56, 31

6 <u>Distributions of large claims</u>

1976 TAYLOR G Testing goodness of fit of an estimated run-off triangle ASTIN Congress 1975 1976 TAYLOR G Separation of Inflation and other effects from the distribution of non-life insurance claim delays ASTIN Congress 1975 1976 BEARD R E Verification of outstanding claim provisions separation technique ASTTN Congress 1975 1974 RAMACHANDRAN G Extreme value theory and large fire losses ASTIN VII 293 "covers previous papers; deals with exponential family of distributions 1972 EERLINER B Correlation between excess of loss cover and reinsurance of the N largest claims ASTIN VI 260 "Poisson claims and Pareto amounts - high correlation" 1972 ANDERSSON H Fire losses in northern countries 1951-65 ASTIN VI 25 1972 FERRARA G Distribution of fire losses by cost ASTIN VI 31 "Italy 1963/65" 1970 BENKLANDER G Distribution of claims according to size in non-life insurance. News bulletin of Association of Swiss Actuaries. 1960 BENKTANDER G & Analytical representation of claim distributions SEGERDAHL with special references to excess of loss TICA 16 1950 TUMA J Second risk reinsurance. First Bohemian R Bank pp.46 "Graphical methods and numerical examples, premiums and categories"

7 Co	insurance	02 1	ກດດ້າສ 🛶	mactical	onnlinet	fond or	nd modelling
0.		VA]	0003.0 -	ا الله ي حيا الله الله حيا الله الله الله الله الله الله الله ال	C. Marcheller		10. 100.40

1972	COLLINS R M	A non-proportional (spread loss) reinsurance pool TICA 1911 633 "a computer simulation model is used"
1972	STRUG E J	Joint underwriting as a reinsurance problem CAS 59, 33 "Dental plan reinsured with Hospital plan"

1971 BOHMAN H & GRENANDER A Mutual reinsurance scheme ASTIN VI 163 "Application of a model - why Pareto not used"

8 Optimal reinsurance and utility theory

- 1975 EENSTANDER G A note on optimal reinsurance ASTIN VIII, 154
- 1973 LEMAIRE J Sur la determination d'un contrat optimal de reassurance ASTIN VII, 165 "the suitability of stop loss; retention and portfolio size"
- 1972 BORCH K The optimal reinsurance treaty ASTIN V, 293
- 1972 DAYANANDA P W A Optimal reinsurance with several portfolios SK ART 1972.14
- 1958 HENEDIKT V Optimising reinsurance results TICA 1811 359
- 1962 BORCH K Reinsurance markets SK AKT 1962, 176 "concept of utility - and a numerical example"

9 Solvency and ruin probability

1971 BEARD R E Calculation of ruin probability for a finite time period ASTIN VI 129 "successive product of distribution functions"

1969 SEAL H L Simulation of ruin potential in non-life companies "various rate making strategies - experience rating shown to be poor" DSA XXI 563

1973 SANKING RW SULVENCY IN NON-LIFE INSULANCE TLAANE

10 <u>Fire data</u>

- 1963 SALZMANN Rating by layer of Insurance CAS Vol 1
- 1962 BANASINSKI A & WANATOWSKI A

Remarks on Statistical Distribution of Intensity of Chance Damages ASTIN II 5