# ACTUARIAL ASPECTS OF MOTOR INSURANCE

by

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'Life is the art of drawing sufficient
conclusions from insufficient premises'—SAMUEL BUTLER

## INTRODUCTION

IN the United Kingdom the customary approach to non-life insurance has been to rely more on the practical experience and flair of the underwriter than on a statistical examination of the experience. In some branches of non-life insurance an office is able to make adequate adjustments to its rates on the basis of claim ratios (i.e. the amounts of claims divided by the premiums) for fairly broad groups. In the more competitive branches such as motor insurance the experience needs to be examined in much greater detail, not merely to satisfy the minimum requirement of guarding against selection of the better risks by other insurers, but more positively in order to find out the extent to which the risk varies with each of the existing rating factors and any possible alternatives. Also, because of the rapidity with which conditions are liable to change, the experience studied must be as up to date as possible if reasonably reliable estimates of the future are to be made.

Although the amount of serious statistical investigation of the experience so far performed appears to have been very limited, several offices have been attempting to study their results in greater detail, but for the most part still in terms of claim ratios. As the number of subdivisions increases, the shortcomings of claim ratios become more and more apparent, and it soon becomes obvious that a different method of analysing the experience is needed. There seems to be a growing awareness that the only satisfactory basis for studying the experience in detail is to study separately the claim frequency and the average amount of claim.

There is an entirely understandable doubt in many minds about the usefulness of statistics of past experience in such a rapidly changing branch of the business, with not merely changing conditions but a

considerable number of selective transfers of business between offices and between different rating categories within the same office. This is an argument in favour of viewing any statistical results and the inferences drawn from them with a healthy suspicion, but it is not an argument for refraining from collecting data in the first place. If there is not sufficient stability to make a statistical treatment worth while, there can be no sound basis for a rating structure. There is certainly plenty of scope for producing misleading results from statistics. The only hope of ensuring that the results will not be misleading is to carry out careful analyses of the risk structure with full awareness of the possible bias due to factors which have been omitted from the statistical model.

Scope for applying statistics to motor insurance is not of course confined to the question of rating (which includes the important subject of no claim discount discussed later in this paper). A statistical treatment is necessary for the proper consideration of technical reserves, whether for the examination of solvency or the periodical review of the profitability of the business. Although there are other applications of statistics in motor insurance, this paper is confined to a discussion of the approach to the determination of premium rates and the measurement of solvency and of profit—all subjects that are familiar to actuaries through their counterparts in life assurance.

Because of the many features that these problems have in common with their counterparts in life assurance, it seems unfortunate that so few actuaries have been associated with non-life insurance. Perhaps the most useful contribution that actuaries can make to the subject is not so much to develop new techniques (although there is undoubtedly scope for doing so) as to emphasize the need to consider the appropriateness of the premium and valuation bases and to question the assumptions underlying any theoretical model. In particular, the problems of selection which permeate the entire subject of motor insurance form an important element in the training of every actuary.

In advocating a much more thorough statistical examination of motor insurance it must be kept very much in mind that if such studies are to be effective the results must be translated into practical terms. Furthermore they must be available in good time and there is always liable to be a conflict between the need to produce some results, even if in a rather crude form, on which immediate action

can be taken and the desirability of a more painstaking analysis to ensure that the crude figures do not conceal some features of importance.

Just as a medical statistician needs to be well informed on the medical as well as the statistical aspects of his work, so the statistician in motor insurance needs to familiarize himself with the whole practical circumstances in which the business is transacted. For example, it is no use amassing data without first becoming familiar with the types of answers actually obtained to the questions on proposal forms, claim forms, etc. Whilst elaborate mathematical models no doubt have their place in the study of motor insurance, and sometimes may be essential if the pitfalls involved in a crude analysis of the data are to be avoided, it is important that they should not become too far removed from reality. Although some useful contributions to the subject have appeared in the *ASTIN Bulletin*, it seems a pity that some of them do not show much more clearly an awareness of the likely discrepancies between the mathematical models and the real world. The value of some of these models may increase when more reliable data have become available. Meanwhile it would appear that the most urgent need is not the development of new mathematical techniques but the development of methods of obtaining well controlled and well defined data which can then be subjected in the first place to some relatively elementary forms of analysis.

To keep this paper within bounds, attention will be confined to the problems of obtaining and using data relating to the experience of a single, reasonably large office. Further considerations arise when considering the pooling of data from different offices with a view to obtaining as comprehensive a picture of the market as possible.

## LIMITATIONS OF THE STATISTICS

It is easy to decide that a statistical approach is essential to the sound conduct of motor insurance, but when the problem is examined in detail it has to be admitted that the prospect is not very encouraging. The circumstances of the business and the way in which it is transacted seem almost to have been designed to frustrate the application of statistical methods.

In the first place, the answers to some of the most important questions relating to the risk are not available to the underwriter, and by the nature of the business it is unlikely that reliable answers

to some of these ever will be. The policies most commonly issued on private cars cover the driving of the insured car by unspecified drivers and (for third party risks) the driving by the policyholder of unspecified cars. The mileage that will be driven during the year (probably the best measure of exposure) is not known and the exposure can be allowed for only indirectly and to a limited extent. Such details as are available to the underwriter and hence for statistical analyses are those obtained when a proposal or endorsement application is completed and in some cases are not kept up to date.

The considerable changes that occur from year to year have already been referred to. There are changes in environment (e.g. increasing cost of claims due to higher repair costs and higher awards for personal injury, improved vehicle performance—which may improve or worsen the claims experience—changing weather conditions and increasing density of traffic); changes in the circumstances of individual risks (e.g. changes in the use made of the vehicle, and additional members of the family starting to drive the car); changes due to action by the insurers (e.g. changes in the rating structure and in the rates themselves, including changes in NCD scales and in the imposition of compulsory excesses or allowance of discounts for voluntary excesses, better control of garage repair costs, and changes in knock-for-knock or sharing agreements); and possible changes in the attitudes of the policyholders towards making claims. Because of all these changes it is necessary that the experience examined should be as recent as possible. Unfortunately the total amount for which the recent claims will be settled may not be known for some years, and some form of estimation is needed in respect of claims that are still outstanding. Whether the estimation is performed by the examination of individual files by claims estimators or by using factual data in respect of claims that have already been settled, the estimating process introduces a further element of uncertainty.

A feature of the business which casts some doubt on the usefulness of the statistics relating to amounts of claim is the knock-for-knock agreement. Since it is virtually impossible to find out what the payments would have been if the knock-for-knock agreements had not been in operation, any results obtained in circumstances in which knock-for-knock agreements were in operation may be invalidated if any change in those agreements is made. It is certainly not appropriate

to assume that payments made under knock-for-knock agreements will cancel each other out as between different types of policy. For example, many claims that would be paid in respect of third party policies if liability had to be determined are in fact paid in respect of comprehensive policies belonging to third parties.

Selection must be borne in mind in any study of the experience of a single office. The types of policyholder an office has attracted in the past will be a select group because of agency connexions, under-writing policy, etc., and it cannot be assumed without question that if an office alters its rates in accordance with its own observed experience the business it will end up with will be similar to that from which the statistics were derived. There is undoubtedly a good deal of selective transfer between insurers, and these transfers may often be the factors deciding whether an office makes a profit or a loss. However, the effect of this form of class selection should not be overstated. If an office has collected reliable statistics indicating that the rates for certain rating groups were considerably too high, it would normally be justified in altering its rates in the direction indicated even though it might be wise not to alter them to the full extent if this meant a substantial departure from the rates of its main competitors.

An obvious feature of the statistical problem of motor insurance is the large number of factors associated—or thought to be associated—with the risk, even if we confine our attention to the data available to the underwriter. Many correlations will exist between these factors, and careful analysis is needed if the variation attributable to each factor is to be distinguished. The large number of possible subgroups means that the number of cases included in the analysis should be as large as possible. This is particularly so when considering amounts of claim, because of the large variance of the size of claim. It means that for most offices the prospect of obtaining useful results from samples will tend to be slight unless the sampling fraction is prohibitively large. It is often difficult to obtain satisfactory samples from the manual office records because of the risk of bias due to the high proportion of movements, and it seems likely that as magnetic tape records are established the tendency will be to analyse data in respect of the entire business.

When embarking on any statistical investigation it is necessary to consider the definition of terms. In the case of motor insurance one must decide what constitutes a claim, what payments are to be in-cluded in the amounts of claim and in what categories, and so on.

It is not safe to assume that consistent definitions already apply within an office at the present time or that the definitions used at present have applied consistently in the past.

## BASIS OF THE STATISTICS

Since such statistics as are produced at the present time as a basis for rating are almost entirely expressed in the form of claim ratios, it is necessary to begin by noting the shortcomings of such ratios.

When dealing with a large section of the portfolio it is natural to want to compare the amount of money paid out in claims and expenses with the amount of premiums charged, and provided the outgo and income are correctly related to each other these broad figures can be a useful guide. Provided also that the expenses can in most instances be regarded as a uniform percentage of the premiums, the claim ratio, found by dividing the amount of claims by the premiums, is a convenient index figure. However, when we wish to examine the experience in greater detail in order to find a basis for calculating future premium rates, claim ratios are no longer suitable.

The premiums charged in the past are considerably affected by the rates of no claim discount which applied, and the changes in basic rates and in no claim discount scales make it difficult to interpret the premium figures which form the denominators of all the different claim ratios. In fact, when dealing with subgroups the attempt to relate the claims experience to the premiums that happen to have been charged in the past seems an unnecessary complication. Since what we are trying to arrive at are the premiums that should be charged in future, the best approach seems to be to look at the amounts of claim per policy year (or vehicle year) of exposure, adjust these where necessary to provide for the anticipated future experience, and add provisions for expenses, profits, etc., so as to arrive at provisional office premiums. It is at this stage that a comparison with the existing premiums can be helpful, but these existing premiums should be those payable according to the current table of rates and not necessarily those charged during the period over which the experience has been examined.

Measuring the exposures in terms of policy (or vehicle) years rather than amounts of premium simplifies the collection of the data.

Having in effect changed the denominators of the claim ratios, we can now turn our attention to the numerators. The first difficulty we meet here is that if the experience examined is recent enough to be of much value, there will be an appreciable number of outstanding claims for which estimates are required. If individual estimates have to be made, not only is the administrative work considerable (with the result that production of the data is likely to be delayed) but we are introducing an element of guesswork into the data and thereby casting some doubt on the validity of the results.

The wide variation in amounts of claim means that the results for even a moderately sized subgroup can be seriously distorted by the occasional large claims, and consequently we soon reach the point at which further subdivision produces results which defy interpretation.

Because of these difficulties it is necessary to break down the amount of claim per unit of exposure into its component parts, namely the claim frequency and the average amount of claim. This has several advantages. The factors most closely associated with the claim frequency are not necessarily those most closely associated with the average claim. The analysis of claim frequencies can be performed on fairly recent claims without any estimating problem, and because we are dealing with numbers of claims and not amounts of money, the data can be broken down into much smaller subgroups.

The fact that a finer subdivision of the data is possible when studying claim frequencies is useful since it seems likely that a considerable part of the variation in experience between rating groups is due to varying claim frequencies. We shall have to be content with relatively broad groups when analysing the amounts of claim. The study of average claims is required not only for rating but also for the study of the statistical problem of estimating reserves for outstanding claims.

Thus for rating purposes, the approach will be to study recent experience of claim frequencies in order to decide on appropriate frequencies to assume for the future, and to study amounts of settled claims in order to estimate not merely the amounts for which the claims already reported will be settled but the average amounts of claims that will occur in future. The product of the estimated claim frequency and the estimated average claim gives a net premium to which can be added loadings for expenses and profits and whatever loadings may be considered necessary for building up a fluctuation reserve.

Having separated the two elements of the net premium, it is obviously important to ensure that there is consistency between the numbers of claims included in the numerators of the claim frequencies and those used in the denominators of the average claims.

## CLAIM FREQUENCIES

Since it seems likely that a considerable part of the variation in the cost of claims per vehicle insured is due to variations in claim frequency, it is desirable that the frequencies should be analysed in as much detail as the volume of data will allow.

There are several possible approaches to the calculation of exposures and the most appropriate method will depend on the circumstances of the office and in particular the form of mechanization. It is advisable that the exposure should relate to a calendar period of 12 months rather than to the policy years starting in a 12-month period, since the experience examined is more up to date and there are several administrative advantages.

The exposures can be built up from the various types of movement as they occur, or found by the census method. With the trend towards establishing magnetic tape files for the business in force, the advantages for the future at any rate seem to be with the census method, since censuses can be taken relatively easily during the periodical processing of the tape in-force file, and the need to accumulate a large number of separate movement records is avoided. Furthermore, the changing of the factors included in the statistical analyses poses a less severe problem with the census method. Censuses at quarterly intervals should certainly be adequate.

The policies shown on the tape file as being in force will not represent the current insurance position because of the time lag in notifying movements to the file, and there is also a time lag in notifying claims. Because of this, there is much to be said for retaining unit records on the tape file for some time so that censuses can be taken of the more or less correct insurance position a few months in arrear and so that for practically all claims the rating factors applicable at the date of accident can be extracted automatically.

The stage at which the data for individual policies are summarized into analysis groups will depend on the amount of detailed analysis being attempted and the type of equipment available. The number of possible classification cells is so great that if we were to summarize

according to all the factors simultaneously we should produce almost as many summary records as we had individual records to begin with. With magnetic tape equipment it is becoming reasonable to retain individual policy records as the basis of the statistical analyses, but these analyses need to be carefully planned to keep the processing time to a minimum.

For policies insuring a single vehicle, the claim frequency is found by dividing the number of claims that occurred within the exposure period by the number of policy years of exposure. For policies insuring more than one vehicle, the numbers of vehicle years should be used for the exposures, but it may be advisable to analyse the experience of multi-vehicle policies separately.

The rating factors included in the investigation should include all those currently used in rating and any others that may be related to the risk and for which reliable details are available. Some details of the recent claims history are required, preferably extending over a few years and including dates of claim and an indication in the case of each claim of whether NCD was allowed or not. For private cars the factors should include the type of cover, details of excesses and driving restrictions, class of use, rating area, make of car and some indication of the model, year of manufacture, date of birth of policy-holder, and whether special terms have been imposed. This list is by no means exhaustive, and its inadequacy gives some indication of the complexity of the analysis needed to answer all our legitimate questions. What about driving experience, for example, and the number of years with the present insurer? What about named drivers other than the policyholder and sex and occupation of the policy-holder and so on? If we are to attempt to answer all these questions some form of multivariate analysis is obviously needed, and it remains to be seen how far the established techniques of, say, factor analysis will be helpful.

Interpretation of the results promises to be interesting. To begin with, there are obvious correlations between, for example, NCD category, age of policyholder, age of vehicle and type of cover that need to be sorted out. Then suppose we find that, for reasonably well controlled groups, the claim frequencies are lower for the older cars than the newer ones, for both third party and comprehensive cover. Is this simply because the older cars are driven less or because the third party experience of the newer cars, most of which are insured comprehensively, is materially worsened by the policy-

holders who are refused comprehensive cover, whilst the comprehensive experience of the older cars relates to a select group who wish to insure comprehensively and are allowed to do so or for some other reason? In this kind of situation it is likely that each explanation makes some contribution to the observed variation.

## AMOUNT OF CLAIM

If we are trying to assess the premiums required in the future for the different risk categories by studying the separate elements of risk, we need to estimate the average claim as well as the claim frequency that should be assumed for each rating group in the future. If we are trying to assess the reserves required for outstanding claims, either for the annual accounts or for a more frequent review of the profitability of the motor account, we need to estimate in effect the average amount for which the claims that arose in each year for which claims are still outstanding will be settled.

In each case the estimating of the average claim may be approached by studying the amounts of settled claims, in the hope of finding some pattern that will provide a reasonable basis for making the estimates.

In the first place we need to divide the business into broad categories for which the average claims can be expected to be markedly different. Thus we may start by dividing the claims according to class of business (private cars, motor cycles, etc.) and type of cover (at least into comprehensive and non-comprehensive). How far the claims may be further subdivided depends on the volume of data.

Before attempting any further subdivision, it is worth while taking the claims that occurred in a year that is sufficiently remote for all or nearly all the claims to have been settled and finding the distribution by size of claim. A proportion of the claims will have been settled without payment. The proportion of such zero claims will depend on what an office chooses to call a claim, on the extent of knock-for-knock settlements, and on whether some of the minor expense items are allocated to the individual claims. Provided an office is fairly consistent in its treatment of these matters, the proportion of zero claims may be fairly stable from year to year.

The distribution of non-zero claims will certainly be skew, but its shape can be expected to depend on the office and on the class of business and type of cover. In the case of private car comprehensive

policies it may be found that the non-zero claims follow a distribution that is roughly lognormal, although it may need some adjustment in respect of both very large and very small claims. (Large claims should be taken gross before deducting reinsurance recoveries.)

Because of the skewness of the distribution, the mean claims calculated directly for each category may be distorted by the occurrence of the occasional large claim. There are several ways of trying to overcome this difficulty. One way (but not necessarily the most convenient) is to take as the estimate of the mean claim $exp\,(m+\frac{1}{2}s^2)$, where $m$ and $s$ are the mean and standard deviation respectively of the observed values of $log_e$ (*amount of claim*). This is the maximum likelihood estimate of the mean if the population is distributed lognormally (Benckert, 1962).

When we come to the claims of more recent years we find that an appreciable number remain outstanding, and because the larger claims tend to take a long time to settle the average of these claims is likely to exceed substantially the average of the claims already settled. This tendency is increased by the effect of inflation.

Thus in order to arrive at reasonable estimates of average claims we need to consider two kinds of adjustment, one to reduce the distortion due to large claims and the other to allow for the claims that are still outstanding.

At this point it is advisable to consider the problem of estimating reserves for outstanding claims for the accounts separately from the problem of estimating for rating purposes.

## RESERVES FOR OUTSTANDING CLAIMS

At present the important and generally substantial balance sheet item of reserve for outstanding claims is usually arrived at by the estimation of the outstanding payments on the individual claims by a number of different claims clerks, and at the time the estimates are made it is by no means easy to assess how accurate they are likely to be. A comparison of the estimates with the payments actually made after the estimating date can be made, but by the time these comparisons are available they are too late to be of much value. A statistical approach is needed in order to put a reasonable check on the total of the case estimates. The information that has to be collected in order to do this should in due course provide a basis for

replacing part or all of the case estimating and relying on statistical estimates. It should be emphasized that the statistical approach leaves ample scope for the exercise of judgment regarding the allowance to be made for such factors as inflation and the likely effect of any recent rating changes as regards NCD, excesses, etc.

It should be acknowledged that neither case estimating nor a statistical method can give a very close estimate of the reserve required and there is no substitute for having adequate additional reserves to absorb the fluctuations in the experience. An advantage of the statistical approach is that the details needed in order to check on its accuracy are also the details needed for making the following years' estimates.

Because of the need to try out alternative statistical methods, and also to convince others of the validity of such methods, the best approach is probably a gradual one, starting with the collection of reliable data in the form required for statistical estimating and replacing the case estimating in stages. An acceptable approach might be to start with statistical estimating of the most recently reported claims, for which the case estimates are likely to contain a particularly large element of guesswork, and retaining case estimating for the earlier claims where the information in the claim papers may be supposed to be of the greatest value. It remains to be seen, however, whether case estimating even on the earlier claims—which tend to be the larger ones—will give better results than the statistical approach in the long run.

It is fundamental to a reliable estimate of the reserve for outstanding claims, by whatever method, that the number of claims outstanding should be known reliably. It is essential that strict controls should exist to reconcile the numbers of claims notified, settled, reopened and outstanding. For this purpose it is necessary to define the settlement and reopening of a claim.

Because of the tendency for the larger claims to take longer to settle, it is necessary to divide the claims according to the period from the date of accident (or the date of reporting) to the date of settlement. The problem then is to use the available information in respect of settled claims in such a way as to provide a basis for estimating the amount for which the outstanding claims will be settled.

Direct statistical estimation of the amount that remains to be paid on the outstanding claims is unsatisfactory because of its

dependence on the progress in making partial payments. The required reserve should be arrived at by estimating the total amount for which the outstanding claims will be settled and deducting the partial payments already made.

The outstanding claims should be divided according to the year in which the accident occurred (or was reported) and estimates should be made for each year separately. The approach can be either to estimate the ultimate average claim for all claims including those already settled, or to estimate the ultimate average claim for only those claims that are still outstanding. The former method uses average claims that progress more smoothly from year to year, but of course they need to do so since the estimate in respect of the outstanding claims emerges as the difference between two large figures.

It is beyond the scope of this paper to discuss the techniques that may be used in making the estimates. There are several possible approaches. One is to see how the average settled claim varies with the time taken to settle the claim. However, since the rate at which claims are settled will vary from time to time because of varying pressure of work and changing office systems, the most useful type of adjustment may prove to be one that is based on the proportion of claims still outstanding. Until reliable data on a fairly large scale have been collected, one cannot assess how effective such an approach might be. Whatever the approach, consideration has to be given to the method of allowing for inflation.

Reference may be made to Masterson (1962).

## AVERAGE CLAIMS FOR RATING

The uncertainty introduced by the time lag in settling claims affects the calculation of average amounts of claim for rating purposes. Here we require not merely to estimate the ultimate average amount of all claims that have been reported as having occurred within a given period, but to estimate the average claims that should be assumed in the future. However, if it is attempted to include in the analysis the most recent claims, the degree of uncertainty introduced into the figures will be too great. It is therefore advisable, when considering average claims for rating, to confine attention to claims having occurred at least six months previously.

There are several rating factors which it may be considered are likely to be associated with the average size of claim. Unfortunately

it is difficult to produce significant results, because of the distortion of the average claims of the smaller subgroups by the occasional large claims. Nevertheless, the average claims should be analysed to the extent that the data allow. It is advisable to analyse separately the claims up to, say, £500, and to note the proportions of zero claims.

Among the factors which may be associated with the average size of claim are the NCD category, the excess category, the area of the country and the age of the vehicle.

The effect on the shape of the claim distribution of the presence of excesses, whether voluntary or compulsory, and of the discouragement to make small claims due to the effect of NCD, is difficult to predict. In the case of excesses, for example, notification of damage costing less than the amount of the excess may or may not be made and be counted as a claim, and where excesses are confined to the 'own damage' section of the policy some payments that would have been made in the absence of the excess will still be made, but under the third party section of another policy.

The distribution of injury claims by amount will differ materially from that of damage claims, and useful information may be obtained by dividing the claim payments according to type. It must of course be borne in mind that several types of claim may result from a single incident.

## NO CLAIM DISCOUNT

The system whereby discounts are allowed from the basic premiums in the light of the individual claims experience is a firmly established feature of motor insurance in the United Kingdom. It requires careful consideration, both in order to see whether the existing systems can be improved upon and in order to judge the effect that the systems already used have had on the statistical results.

When a completed proposal is examined the premium found by reference to the table of rates may be modified by the underwriter on the basis of factors outside the current rating structure. If by this means it were possible to define the risk within fairly narrow limits, no adjustments based on the individual claims experience would be necessary. In practice, within any definable group, there will always be a considerable variation in the individual risks due to factors which cannot be made the subject of questions on proposal forms.

Mileage is an obvious example of a factor on which reliable answers could not be obtained. Consequently, within any rating group the policyholders who have made claims, at least of certain types, can be expected to have a higher average risk of making future claims than those who have not made claims. Thus, if an insurer were to charge the same premium for all policies within a given rating group regardless of the individual claims experience, he would be exposed to selection of the more favourable risks by other insurers. The question arises whether a satisfactory automatic system of adjustments can be devised. The no claim discount systems so far used represent an attempt to provide an answer in a form that is acceptable to the public and reasonably simple to administer.

Claims vary considerably in character as well as in cost, and it may be decided to ignore certain types of claim for the purpose of the adjustment. The criteria for deciding which claims should be ignored are a matter for the individual insurers to decide and will not be discussed in this paper, but it is desirable that some rules should be laid down to ensure consistency.

The adjustment in terms may take the form of an alteration in cover (e.g. by imposing excesses or by limiting to third party cover) or adjustments to the future premiums. Most of the adjustments made in the United Kingdom are the adjustments in premium resulting from the NCD system, and attention will be confined to premium adjustment schemes.

In any adjustment scheme, it is necessary to specify what features of the individual claims experience are to be taken into account, what type of adjustment is to be made, and how big the adjustments are to be. It is natural to ask whether there is some way of deciding whether one scheme is better than another, and in fact whether there is some ideal scheme which is in some way better than all its competitors. The problem proves to be an intricate one, but there are indications that some useful progress can be made. The difficulty, however, is not so much in devising internally consistent mathematical models but in deciding how far such models are relevant to the real world of motor insurance.

Having decided what types of claim are to be taken into account in adjusting the premiums, it is undesirable to make the adjustments depend on the size of the claim. It is by no means obvious that the size of past claims is a reliable predictor of future claims, and the administrative complications that would result from an attempt to

make the adjustments depend on the size of claim (which may not be known for some years) are considerable.

The extent of the claims history of the individual policyholder that should be taken into account is limited partly by the fact that circumstances may change to such an extent that the claims experience of the earlier years becomes of doubtful relevance, and partly by the difficulty of obtaining reliable information about the earlier claims experience in the case of transfers from other insurers. It is easy to find the latest rate of NCD offered by the previous insurer, but it is not practicable to obtain full details of all claims with previous insurers (and the information would be difficult to interpret anyway).

Until recently the usual type of NCD scale comprised $n$ categories $0, 1, 2, \ldots, n-1$, with the rules that new policyholders not previously insured started in category 0, and a policyholder moved from category $r$ to $r+1$ after a year without a claim and from $r+1$ to 0 after a year with at least one claim ($r = 0, 1, \ldots, n-2$). A recent modification has been to provide for a maximum fall of two categories after each claim. One version of this has the further feature that a policyholder with $n$ years free from claim (where $n = 4$) is granted a virtually permanent percentage reduction from the premium independently of the normal NCD.

The last mentioned scheme is an interesting one in that it singles out for preferential treatment the policyholders who have had a spell of four years free from claim. Even among policyholders with an annual risk (assumed constant for this illustration) as high as 30% of making at least one claim that will result in disallowance of NCD, 24% will be free from claim in the next four years, and in a period of ten years 63% of them will have had a spell of at least four years free from claim. Only a small proportion of policyholders will fail to qualify in the long run for the additional discount. The decision having been taken to give preferential treatment to the policyholders with four years free from claim, it is not obvious why this rather elaborate two-stage system was introduced instead of simply providing that the preferred policyholders would not fall back beyond category 1.

There is obviously scope for research to try to find the form of claims history that is most suitable for use in a premium adjustment scheme.

The type and size of the adjustment will now be considered. Since the need for an adjustment scheme arises because the cases within the

rating groups are not homogeneous, it seems reasonable to suppose that the greater the heterogeneity the larger the adjustments will have to be. It would therefore be useful if we could estimate the form of the risk distributions for typical rating categories. Delaporte (1965) has attempted to do this by assuming risk distributions of Pearson Type III form and estimating the parameters from observed numbers of policyholders with 0, 1, 2, . . . claims in a given period. If we assume a Type III risk distribution and combine this with a Poisson distribution assuming a constant risk for each individual case, the numbers with 0, 1, 2, . . . claims will correspond to a negative binomial distribution. It is, however, doubtful whether the assumption that the risk for an individual policyholder remains unaffected by his own claims experience is reasonable (especially if an NCD system is already in operation, on account of 'hunger for bonus' referred to below), and even if we do find we have a negative binomial distribution it does not follow that we can work back to a Type III risk distribution. The Type III distribution is probably a reasonable one to experiment with, but more research seems to be needed to find out how sensitive the results are to the assumptions that are being made. Beard (1964)(2) has experimented with distributions based on annual mileage figures.

Any system of adjusting the terms of the policy in the light of the individual claims experience involves some discouragement from claiming, especially from making small claims. In the context of no claim discounts (which used to be generally referred to as no claim bonuses) this has been called 'hunger for bonus'. Since this almost certainly varies with the NCD category, it is difficult to distinguish the effect of hunger for bonus from the selective effect of the NCD scale. The difficulty is made worse by the effect of selective transfers between insurers and between rating groups (e.g. on change of car).

Studies of the kind made by Delaporte lead to adjustments that vary from one rating group to another. This is what one might expect, since it is scarcely likely that the uniform percentage adjustments of the typical NCD system would be equally appropriate for all rating groups. In fact, for a rating group with 20% claimants and 80% non-claimants within a year, a discount of 10% for the non-claimants can be balanced by a loading of 40% for the claimants, whilst for a rating group with 10% claimants and 90% non-claimants the same percentage discount requires a loading of 90% to balance it.

One feature that is noticeably lacking from the present NCD

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systems is any arrangement for automatic loadings beyond the basic premium. As far as the NCD system is concerned, the starting premium is also the maximum. Since the average rate of discount under the new private car scales is likely to be in the region of 45%, new policyholders with no previous experience will probably be paying at least 75% above the average premium, even after allowing for loadings on policies with a poor claims experience. Whilst a lack of insurance experience is no doubt correlated with a lack of driving experience (which may justify some loading as well as the imposition of an excess), it would seem that the entrance fee to insurance is becoming rather high and that new policyholders may be tending to subsidize those who have been insured for some years. What is obviously needed in examining the experience is to separate the policyholders who are on low rates of NCD because of recent claims from those who are on low rates of NCD because they have only recently been insured.

It is possible to develop premium adjustment schemes that differ markedly from any of the NCD systems so far used. Some of these appear to offer considerable theoretical and practical advantages over the NCD systems, but it seems likely to be several years before the introduction of any radically new scheme could be contemplated. There are obvious dangers in departing too rapidly from the established structure of the market, especially while the available statistics leave so much to be desired. Furthermore, however theoretically sound a scheme may be, one must consider whether it is likely to prove acceptable to the motoring public.

## VALUATION

The assessment of the technical reserves required in motor insurance is similar in concept to the valuation of the liabilities in life assurance, and the purpose of the valuation must be borne in mind in choosing the bases to be used. It is convenient to begin by considering the calculation of the reserves in order to test the solvency of the fund, and because special considerations apply in the case of a recently established fund, it will be assumed that the fund has been in operation long enough for a reasonable amount of past experience to be available.

The problem of determining an appropriate reserve for outstanding claims has already been referred to.

A further reserve is required for claims that will have occurred before the valuation date but have not yet been reported. The average delay in reporting claims around the end of the year will vary from office to office. The numbers of late reportings in various categories at the current valuation date can be estimated sufficiently accurately by reference to the late reportings in previous years, paying due regard to weather conditions, and suitable average amounts of claim can then be applied.

A reserve is required to cover the claims and expenses in respect of the remainder of the policy years for all policies still in force on the valuation date. This is known as the reserve for unexpired risk and it has become customary to take it as a percentage (normally 40% but sometimes higher) of the premiums payable in the year just ended. This is a retrospective reserve and the 40% can be arrived at by deducting 20% from the premiums to allow for commission and initial expenses and spreading the remaining 80% evenly over the policy year, assuming an even spread of business over the year and that all policies run for one calendar year. For testing solvency, this type of reserve is inappropriate; what we need is a prospective reserve. If the premiums are inadequate (and this possibility does exist in motor insurance) a retrospective reserve is obviously liable to be inadequate also. A prospective reserve should strictly be based on assumed claim frequencies and average amounts of claims and expenses derived from an examination of the experience, but in practice it may be necessary to make some fairly broad assumptions.

A reserve should be made for the run-off expenses. This should be based on an analysis of the expenses, but it will seldom be appropriate to attempt a precise estimate.

Because of the uncertainty surrounding the estimates of these various reserves, it is obviously desirable that a substantial provision should be made for adverse fluctuations. As in the case of life assurance, this provision can be made partly by taking margins in the bases used for the normal reserves, but the relative importance of additional reserves in motor insurance means that they deserve special consideration. It would go beyond the scope of this paper to discuss in detail the determination of appropriate margins of solvency, and reference may be made to Pentikainen (1962) and Beard (1964)(1) and (1966).

For an established office the main interest in the reserves lies not in testing the solvency of the fund but in measuring the profit earned

during the year. This should be analysed according to the year of exposure to which it refers.

An element of profit is liable to arise in respect of each year of exposure for which there are still claims outstanding at the start of the valuation year. Thus we may start by finding the adjustments to be made to the amounts of profit previously calculated for these earlier years.

Since we are calculating the profit for the separate calendar years, we need to apportion the premiums to the years of exposure. The expenses should be similarly apportioned, and the approach is therefore equivalent to taking a retrospective reserve for unexpired risks. However, if the examination of the recent experience suggests that the current premiums are unprofitable, provision should be made for the anticipated loss in the following calendar year. This is equal to the difference between the prospective and retrospective reserves for unexpired risks.

How far it is desirable to go on breaking down the accounting results will depend on the size of company, the size of its additional reserves and the importance it attaches to its motor account. In so far as decisions are taken on the basis of the accounting results, it is desirable that they should present as clear a picture as possible. The present form of published accounts certainly does not do this, and the so-called underwriting profit has very little significance unless it is broken down into the separate years of exposure.

The main benefit of a statistical approach to the assessment of reserves should be to indicate the degree of confidence that can be placed in the results. This is particularly important in the case of outstanding claims because the error may be substantial. There seems to be a case for more consistency in the approach to the different reserves. There seems little point in striving for an unattainable precision by continuing indefinitely with laborious case-by-case estimating of reserves for outstanding claims, while accepting readily an arbitrary reserve of 40% (or any other fixed percentage) of the premiums for unexpired risks.

## GENERAL COMMENTS

The aim of this paper has been to indicate the main aspects of motor insurance that appear to be susceptible to actuarial treatment, and to suggest some of the questions that should be asked, rather than

attempt to supply answers. Many of the answers could not be found at this stage because of a lack of data in the required form.

The next stage must be to collect such data. Now that magnetic tape files are coming into use, there is an opportunity to examine the experience in relation to a much wider range of risk factors than has been practicable hitherto, but it will take some years to build up enough data to give a complete picture, especially in respect of average claims.

It is sometimes thought that the purpose of using computers for analysing motor insurance experience is to enable the rating to be made more complicated by taking account of more and more factors. It is to be hoped that the reverse will be the case. The most encouraging outcome of a detailed investigation would be to find that the supposed association of many of the factors with the risk was spurious. If a statistical study can get rid of some of our pretensions regarding the precision with which risks can be assessed it will certainly serve its purpose.

It has been suggested that if we investigate the experience in greater detail we shall eventually reach the stage at which we are charging each policyholder with the cost of his own claims. Not only is this manifestly impossible with an average of one claim in every five years or more because of the time taken for the individual experience to show itself, but in view of our present ignorance about so many of the statistical features of the business it scarcely seems to be our most pressing concern. In any case, as has already been pointed out, there are many questions that it seems we shall never be able to answer. This is in one sense reassuring, since it means that however much we examine the experience we shall still be left with a large area of residual ignorance that leaves plenty of scope for insurance.

The study of motor insurance is a fascinating one that goes far beyond the range of statistics. There are so many questions to which one would like to know the answers that it is difficult to know where to begin. It is hoped that this paper has pointed out some of the possible starting points.

## ACKNOWLEDGMENTS

who has undoubtedly made more contributions to the study of non-life insurance than any other British actuary.

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