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# MOTOR INSURANCE STATISTICS

by

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## I INTRODUCTION

THE object of this paper is to look at some of the practical problems which have to be faced in an analysis of motor insurance statistics and to point towards some of the solutions. In order to cover the ground, it has not been possible to examine any of the issues in any great depth and only private car insurance is considered. Much of the theoretical background to the subject has already been very ably put to this Society—in particular in papers by R. E. Beard and P. D. Johnson—with the result that a certain element of repetition has been inevitable, but this paper is in no way intended to be a complete theoretical treatise. The intention has been to consider various problems, discuss some actual statistics and their implications and then to continue. It is hoped that this may lead to a better understanding of the practical issues involved and at the same time may encourage others to delve into a quite entrancing subject which offers considerable scope for useful research.

I am very grateful to the office for which I work for being given permission to reproduce some of their statistics; this is the source of all the figures used, apart from the theoretical model introduced on page 218, and they all refer to 1967. The opinions expressed are however entirely my own and do not necessarily coincide with those of my office.

## II THE PROBLEM

It would be wrong to begin the paper without emphasizing two issues which are fundamental to the underwriting of motor insurance. First, the severity of competition, which is stimulated by the necessary annual renewal of each policy, has led directly to the complexity of the present rating structure in motor insurance. This complexity has not been introduced, as has been suggested in the past, simply on the

grounds of equity between policyholders. It has been due to the continual search for distinguishable areas or pockets of the account which are over-rated and which can therefore be exploited at the expense of other companies. If one company charges a premium of £20 over a group of cars which could be broken down into two groups at £15 and £25, another company will spot this differential, offer a premium of £15 10*s*. for the '£15' group and take the business at a profit while the original company is left with the '£25' business at the £20 rate and a fast deteriorating experience. This is what has been happening in the industry over the last few years on a very large scale—though some new companies have gone too far. The result has been this ever-increasing complexity of the rating structure and there is no indication that the movement is yet at an end. The Americans use a more complex structure than our own and they have statistics to justify it. It is an irreversible trend while free competition continues.

The second issue is the rate of change of insurance experience which is such that there is a very real need for up-to-date statistics. Consider some of the changes taking place:

over the last 5 years the average annual rate of increase in the cost of a claim has been over 5% in the author's office;
the average life-time of a comprehensively insured car is little more than 4 years;
the introduction of larger rates of no claim discount which lead to an apparent sudden drop in claim frequency and an increase in average claim cost;
the new laws on driving under the influence of alcohol;
the effect of the payroll tax, not only on expenses but also on garage repair charges.

It should thus be clear that statistics based on experience which is only two years old will have little value for the future until they are adjusted to allow for the changes which have taken place and which are likely to take place.

There are three principal problems in the analysis of motor insurance statistics and these are considered in this section together with some comments on the make-up of the premium:

(*a*) The distribution of the cost of a claim, being approximately lognormal (with a few very large claims), is such that a very large number of claims are required if the results of an analysis can be said to be credible. See page 216.

(*b*) There is often a considerable period of time between the occurrence and settlement of a claim and in particular the larger ones take longer to settle. This tends to delay the production of reliable claim cost statistics. See page 216.

(*c*) There are many risk factors which seem to have a considerable bearing upon the claims experience. There is an element of correlation between many of them, but because of (*a*) and (*b*) it is not easy to assess its extent. See below.

Table 1

| *Comprehensive cover* | Relative claim frequency | Relative cost per claim |
|---|---|---|
| All private cars | 100 | 100 |
| excluding most business use | 95 | 101 |
| including most business use | 125 | 97 |
| cars garaged in a major town | 123 | 93 |
| all other cars | 80 | 106 |
| insured over age 30 | 90 | 97 |
| insured age 30 and under | 150 | 105 |
| car year of make 1961 to 1966 | 110 | 105 |
| car year of make 1960 and before | 70 | 96 |
| some small family cars | 81 | 94 |
| all other cars | 104 | 101 |
| no claims in previous 3 years | 69 | 104 |
| remainder | 126 | 98 |
| *Non-comprehensive cover* | | |
| All private cars | 80 | 50 |

The only two practical units of exposure to risk are car years and premiums. Premiums are only relative to a particular rating structure and in order to give some idea of the absolute claim experience within each of the risk factors the unit of a car year is necessary; this is one car insured for a year or four cars for a quarter, etc. The claims experience is given by the average claim cost per car year, but it is useful to break this down into its two components: claim frequency and average cost per claim. Table 1 shows the relative claim frequencies and the relative average claim costs for a number of risk factors. The base for both frequency and cost has been taken as that for all private cars with comprehensive cover. The results are partly those in 1966 and partly in 1967, and are considered to be not unrepresentative of the market.

The object of the table is to show the extent of the variations in the experience due to six risk factors and it is noteworthy that more of the variation is in the claim frequency than in the average cost of claim. The categories have not always been exactly defined nor have they been broken down very finely, no category containing less than 15% of the whole exposure. However, it should be sufficient to illustrate something of the complexity of the situation. No attempt has been made to remove correlations which may exist between any of the factors. An analysis on these lines but with more subdivisions cannot in any way be used for premium rating purposes until the possible correlation between the factors has been examined. The variations in one, or more, of the factors may be completely explained by variations in others, thus reducing the necessary rating factors.

One way to find the true variation caused by each factor is to break down the data by more than one factor at a time. The ultimate would be to subdivide by each of the seven factors at the same time. But if there are only five subdivisions within each of the seven groups, this would represent $5^7$ or almost 80,000 separate cells which is quite unthinkable, and yet some such analysis is really needed. Theoretically it is possible, but in practice such a large number of the cells would contain data which were quite insignificant. Consider the two factors: class of use and no claim discount (NCD). Because the claim frequency is greater amongst the business users, it is inevitable that the average rate of NCD will be less. Thus in calculating the scale of premiums the loading for business users should allow for the fact that there will be this smaller discount, otherwise the business users would be paying twice for their worse experience.

An analysis by year of manufacture of car pointed to a marked deterioration in experience amongst the new cars, yet there is no premium differential by year of manufacture since 1960. The question then to be asked is the extent to which this worse experience is already being paid for within the rating structure. There may be a larger proportion of new cars in the business use category which are therefore already paying extra; amongst the older cars there may be a larger proportion carrying an excess (i.e. the policyholder settling say the first £25 of claim cost) and thereby paying less. It is already clear that the statistic 'claim cost per car year' may give a true picture of the experience which can be followed from year to year to give a trend, but without some expected value to measure it against it is of

very limited use in measuring the limitations of the premium structure or as a guide to profitability.

Within life assurance the standard would be the mortality table as used in the premium basis; but such a table is comparatively simple in that there is only one main variable, namely age, and it serves its purpose for a number of years with only slight modification. In motor insurance there is no such standard nor is there likely to be one, partly because of the speed of change within the experience and partly because of the complexity of such a standard. However, there is a very practical and simple answer which always has been used, that is to compare claims experience with the appropriate premiums by means of the claim ratio (claims/premiums). Some 35% of the premium has to pay for expenses and commission, but as will be seen later, the total expense ratio varies only a little within a private car portfolio, and this variation is defined if the claim cost per car year is also given. Thus the standard can be taken as a given percentage of premiums which can be compared with the actual claim ratio. Alternatively, and more simply, the sum of the claims ratio and the expense ratio, known in America as the Operating Index but little used here, can be compared with 100.

The Operating Index gives an immediate guide to profitability regardless of any correlations of risk factors. The underwriter's aim will be to maximize profits in relation to premium income and there may be a target ratio which would make this statistic all the more fundamental when considering adjustments that may be required to the present premium structure. There are, however, two dangers in using the claim ratio:

(i) in times when premium changes have been made, it may hide a changing claims experience;
(ii) statistics have in the past tended to be produced after quite a long delay, with the result that the premiums used in the denominator may not be those current.

However, it is not usually as difficult to adjust for either of these factors as it is to try to go directly from a claim cost to a new premium structure, such is the complexity of the modern premium basis.

Those who are involved with motor underwriting make very considerable use of this statistic, the claim ratio, simply because it is so vital, clear and understandable. The statistician may and should make use of a lot more statistics in helping the underwriter but in the

end he must reduce the figures to their effect on profits and that comes back to either the claims ratio or the Operating Index.

## PREMIUM BASIS

A typical private car premium might be made up as shown below. The actual amounts and ratios will, of course, vary with offices, and in particular the relative sizes of commission and selling expenses will depend upon the extent of the work done by brokers and agents.

| | |
|---|---|
| Office premium | P |
| Claim cost or pure premium | C |
| Commission | ·1P |
| Selling and management expenses | ·13P |
| Contingencies and profit | ·02P |
| Policy handling | £1. 10*s.* |
| Claim handling | ·1C |

By addition

$$P = 1{\cdot}1C + {\cdot}25P + 1{\cdot}5$$
$$= 1{\cdot}47C + 2$$

This formula produces the following results:

| Claim cost | Office Premium | Claim ratio | Expense ratio |
|---|---|---|---|
| C | P | 100 C/P | 98 – 100 C/P |
| 5 | 9·4 | 53·4 | 44·6 |
| 15 | 24·1 | 62·2 | 35·8 |
| 25 | 38·8 | 64·4 | 33·6 |
| 35 | 53·5 | 65·4 | 32·6 |

Sometimes it is arbitrarily assumed that the expense ratio will be constant whatever the size of the premium. Anyone who has seen the extent of routine processing work involved in handling motor insurance policies will understand the fallacy in that. The exact level of the expense to be allocated on a per policy basis is debatable, but the theory must be unquestionable.

## OPERATING INDEX

This has been defined as the sum of the claims and expense ratios, but each of these needs a more exact definition than has already been given. The object of the claim ratio is to compare premiums with the claim cost to which the relevant policies give rise. This object is not

achieved if the year's written premiums (those which became due as a result of the policies written or renewed during the year) are compared with the same year's claim payments. On the one side the cover provided by 1 year's written premiums will give rise to accidents in the following year and on the other side many of the claim payments will be in respect of accidents which occurred in previous years.

It is necessary to make use of what are called earned premiums; these are given by the product of the written premiums and the proportion of the policy term which is exposed to risk in the period of examination. For a portfolio not subject to any major growth change, this can be given quite simply by the mean of the current and the previous year's premiums since policies are usually written for a period of 1 year.

An exact estimate of earned premiums can be given by a computer though a very close estimate will come from the '1/24th rule' which gives, for the 1967 earned premiums:

1/24 of the January 1966 written premiums
3/24 of the February 1966 written premiums
. . . . . .
23/24 of the December 1966 written premiums
23/24 of the January 1967 written premiums
. . . . . .
1/24 of the December 1967 written premiums

Table 2

*Date of exposure*

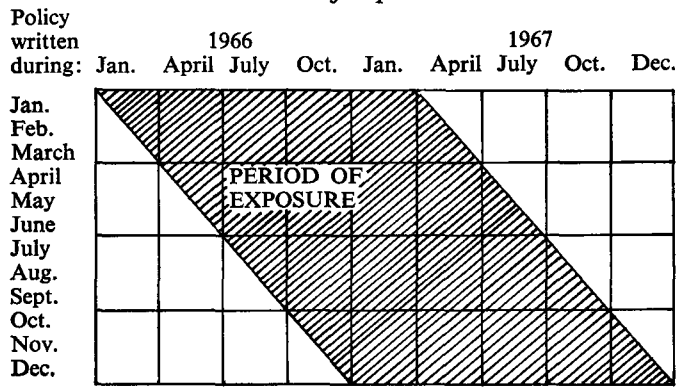


Table 2 helps to make this clear and at the same time illustrates how 75% of the exposure in the first half of 1967 will come from

policies written in 1966, provided business is at a uniform level. That part of the 1966 written premium which is not 'earned' until 1967 is defined at the end of 1966 as the unearned premium.

The claims cost to be compared with the 1967 earned premiums will be the cost of all the accidents occurring in 1967. To be able to produce information soon after the end of 1967, estimates of all the outstanding cost on 1967 accidents will be made. Then an earned claims ratio can be produced for 1967 being:

$$\frac{\text{the expected cost of all claims which occurred in 1967}}{\text{the earned premiums for 1967}}.$$

This can be corrected as the claims are actually settled, should the outstanding estimates not prove to be correct.

Some of the expenses will not be incurred until the final claim is paid, but nevertheless the bulk of the expenses will be paid in the year the policy is written. Thus to compare expenses incurred in a year with the same year's written premiums will, unless there is a very large rate of growth, give a good guide to the true expense ratio. So the Operating Index is defined by the sum of:

(*a*) the earned claims ratio, and
(*b*) the ratio of expenses (including commission) to written premiums.

This gives a convenient and reliable guide to the profitability of a group of business; if this is greater than 100, and the group is sufficiently large to produce a significant or credible result, then some action will be needed to bring it down below 100. It is such a simple statistic, which nevertheless reaches the heart of the problem.

## RANDOM FLUCTUATIONS IN CLAIM COST

The distribution of the cost of some 4,000 claims settled in 1967 from private cars with comprehensive cover is shown in Table 3. It would have been preferable to have examined the eventual cost of all the claims which occurred in a given period, but this was not available. The portfolio from which the claims were taken was growing, but not considerably.

One feature of the table which may need some explanation is the number of 'zero claims'. These are the claims which are reported but

Table 3

*Distribution of the cost of claim settlements by size*

| Claim size | Percentage of claims by Number | Cost | Square of cost of each claim |
|---|---|---|---|
| Zero claims | 21·2 | — | — |
| £1– £25 | 22·6 | 4·2 | 0·2 |
| £26– £50 | 16·0 | 8·5 | 1·1 |
| £51– £100 | 18·0 | 18·0 | 4·5 |
| £101– £250 | 16·7 | 35·9 | 19·7 |
| £251– £500 | 4·6 | 21·0 | 23·5 |
| £501–£1,000 | 0·7 | 6·3 | 13·5 |
| over £1,000 | 0·2 | 6·1 | 37·5 |
| | 100 | 100 | 100 |

Mean = £72
Standard deviation = £127
Coefficient of variation = 1·76

for which no payment is subsequently made. This may be for a number of reasons, such as:

(*a*) the cost turns out to be trivial;
(*b*) a third party pays;
(*c*) the cost is less than the excess on the policy; and
(*d*) the cost is such that the insured considers it is not worth losing the No Claim Discount.

Another feature is the effect of the few large claims: one claim in a hundred is large enough to make up one-eighth of the total cost of the hundred claims and one-half of the sum of the squares of the cost.

The large coefficient of variation implies the need for a very large number of claims before any statistic based on the average claim cost can be of real use and it is worth considering this in more detail. Assuming first that the mean and standard deviation of this group of claims are those of the overall population of claims and that the distribution of the average claim from any sample is normal then the standard deviation of the average cost of $n$ claims is given by

$$£\left(\frac{127}{\sqrt{n}}\right)$$

Table 4 gives the number of claims required in a sample before an average cost of claim as shown can be said to be significantly higher

than the population average of 72. The columns headed car years indicate the number of car years that would be needed to produce that number of claims, given a claim frequency of 16·7%—one claim in 6 car years.

There is, in addition to the fluctuations due to the cost of claim, that due to the variability in claim frequency. The result is that the experience of a very large number of car years must be examined before any credible results can be obtained by comparing either premiums or car years with the total claim cost; the narrower the confidence limits of a given result, the more credible it is said to be. Because of the random fluctuations in the cost of claim, it will clearly

Table 4

| Average cost of claim (£) | Percentage deviation from 72 | Numbers required for deviation to be significantly above 72 | | | |
|---|---|---|---|---|---|
| | | at 5% level | | at 1% level | |
| | | Claims | Car years | Claims | Car years |
| 75·6 | 5 | 3,448 | 20,688 | 6,896 | 41,376 |
| 79·2 | 10 | 862 | 5,172 | 1,724 | 10,344 |
| 86·4 | 20 | 216 | 1,296 | 431 | 2,586 |

be possible to produce credible results from a smaller sample if the criterion is the claims frequency, rather than the cost per car year, though some assumption has to be made on the cost per claim. Another way of reducing the volume required for better credibility is to smooth or graduate the cost of claims. Some methods of doing this are described later in the paper. Claim frequency is certainly a very useful early warning of any change in experience, provided at the same time some attention is also paid to the overall level of claim settlements. Any multivariate analysis which includes cost of claims unsmoothed will need a vast exposure in order to produce useful or credible results.

## DELAY IN CLAIM SETTLEMENT

Motor insurance policies are usually renewed yearly so that one might expect to be able to produce 1 year's claims statistics without much delay. However, a major problem lies in the length of time it takes to settle claims. While many of the small material damage claims can be paid quite quickly, where liability due to bodily injury is concerned there will often be a considerable period of delay between

occurrence and payment. Table 5 slightly overstates the case but it does serve to give an idea of the time involved. The data in the Table are based on the period of time between occurrence and settlement; the date of settlement will sometimes not coincide with the date of payment. Several, or indeed no, payments may be made under one claim. The date of settlement is the date when the claims department decide there is likely to be no further payment. In an exercise to compare delays of payment with those of settlement, there was found to be little difference. The data are taken from some 4,000 private car claims from one office and settled in 1967.

Table 5

*Delay in Claims Settled in 1967*

(Private cars—comprehensive cover)

| Year of occurrence of claim | Own damage payments | | Third party payments Bodily injury | | Third party payments Property damage | | All payments combined | |
|---|---|---|---|---|---|---|---|---|
| | % of cost | Av. cost £ | % of cost | Av. cost £ | % of cost | Av. cost £ | % of cost | Av. cost £ |
| 1967 | 59 | 70 | 14 | 26 | 40 | 38 | 52 | 61 |
| 1966 | 37 | 80 | 41 | 72 | 43 | 52 | 38 | 75 |
| 1965 and before | 4 | 108 | 45 | 323 | 17 | 190 | 10 | 218 |
| TOTAL | 100 | 74 | 100 | 78 | 100 | 51 | 100 | 72 |
| Percentage of all claim cost | 76 | | 9 | | 15 | | 100 | |

The claims which are settled soonest are the small 'own damage' payments and the medical fees under the Third Party bodily injury category. There is a longer delay in the larger Third Party awards which only make up a comparatively small proportion of the overall cost.

The delay has the effect that the cost of a group of claims does not emerge until some 2–3 years after the occurrence of those claims. If statistics are wanted more quickly then estimates must be put on to the cost of the claims. All offices have to face this problem of estimating claims outstanding for their published accounts. They are then interested in the amount still outstanding on claims not yet settled. The value of any motor underwriting statistics will depend very much on the reliability of these estimates and the speed with which they can be produced. Most offices make an individual estimate of the

expected cost still to be paid on each unsettled case. This is a tedious process which can involve considerable unproductive labour.

One of the problems in statistically estimating the value of claims outstanding is the increasing cost of settlement as the delay since occurrence gets longer (see Table 5). It will therefore always be necessary to separate each generation of claim occurrences. Few companies rely on statistical estimation even though there is clearly a case in favour. In the author's company a very simple method is used to give a bulk figure for an estimate of the claim cost outstanding at the end of the first calendar year of the claim. The method of estimation relies entirely on the fact that, of the total amount for which all one years' claims will eventually be settled, a constant proportion has always been paid in the year of claim. The proportion has varied only between 50% and 54% in 15 years. This method, of course, relies upon a large and stable portfolio and a claims organization which is consistent in its speed of settling claims. It is in fact applied to the whole motor portfolio, including private cars, commercial vehicles and motor cycles.

Table 5 refers to claims under cars with comprehensive cover. Where the cover is not comprehensive, the average delay in settlement is longer because of the greater proportion of bodily injury claims.

Before leaving this section of the paper describing the problem, it is necessary to consider the quality of the data being used in any analysis. Because of the sheer volume both of numbers of policies involved and in the amount of information to be coded, and frequently to be recoded, a considerable amount of attention should be given to the possibility of errors and omissions. No statistics should ever be accepted unless they can be reconciled, and the best reconciliation will be with the accounts which have to be audited.

## III RESERVES

### OUTSTANDING CLAIM RESERVE

One of the major problems of an insurance supervisory authority is in confirming the adequacy of the reserve for outstanding claims. Factors affecting the size of this reserve in particular are:

(*a*) the speed with which a company settles its claims;
(*b*) the relative proportion of bodily injury claims (which will vary with the proportion of non-comprehensively insured cars);
(*c*) the rate of growth of a company.

It is interesting to look at the last of these factors in more detail. Consider first a company in a stationary position with both written and earned premium of 100 and claims of 60. The claim payments are such that:

50% is paid in the year of accident,
30% is paid in the first year after the accident,
10% is paid in the second year after the accident, and
10% is paid in the third year after the accident.

Then of the claim payments of 60 made in 1967,

30 are from 1967 accidents,
18 are from 1966 accidents,
6 are from 1965 accidents, and
6 are from 1964 accidents.

The outstanding claim reserve at the end of 1967,

$$\begin{aligned} \text{is } 6 &= 6 \text{ from 1965 accidents,} \\ 6+6 &= 12 \text{ from 1966 accidents, and} \\ 6+6+18 &= 30 \text{ from 1967 accidents.} \\ \textit{Total}\ \ 48 & \end{aligned}$$

Thus, with the company in a stationary position, the outstanding claim reserve is 48% of written premiums. If, however, the company had been growing, the reserve held for older claims would bear a smaller relationship to the current volume of premium and the 48% could be reduced. In the next paragraph the extent of this reduction is considered on the simple hypothesis of a compound interest growth but with yearly rests. This assumption makes the algebra simpler and, surprisingly, has a negligible effect on the final results.

Now suppose written premiums which were 100 in 1967, had been expanding evenly at $i\%$ a year. The 1966 written premiums are $100v$.

Then the 1967 earned premiums are $\frac{1}{2} \times 100\ (1+v) = 50\ (1+v)$. Since the outstanding claim reserve in respect of any year's accidents will vary in proportion to that year's earned premiums, the 1967 outstanding claim reserve is

$$\begin{aligned} & 6 \times \cdot 5 \times v^2(1+v) && \text{from 1965 accidents} \\ & +12 \times \cdot 5 \times v(1+v) && \text{from 1966 accidents} \\ & +30 \times \cdot 5 \times (1+v) && \text{from 1967 accidents} \\ & = 15+21v+9v^2+3v^3 && (1) \end{aligned}$$

This formula gives the following values for the outstanding claim reserve for each 100 of written premium for various rates of expansion.

Table 6

| Annual rate of expansion | Outstanding claim reserve |
|---|---|
| NIL | 48 |
| 10% | 44 |
| 25% | 39 |
| 50% | 34 |
| 100% | 28 |

Similarly the 1966 outstanding claim reserve is

$$(1) \times v = 15v+21v^2+9v^3+3v^4 \qquad (2)$$

Therefore the amount required to increase this reserve during 1967 is

$$(1) - (2) = 15+6v-12v^2-6v^3-3v^4 \qquad (3)$$

Now if the reserves were maintained at only three-quarters of their required level, a surplus would emerge in 1967 of

$$\tfrac{1}{4}(3) = \tfrac{1}{4}(15+6v-12v^2-6v^3-3v^4) \qquad (4)$$

Moreover while the expansion continues at $100i\%$ p.a. the apparent surplus given by (4) would continue to emerge as a constant percentage of written premium. With expansion at 25% and 50% per annum the apparent extra surplus emerging would be 2% and 3% respectively of written premiums. If the reserves were maintained at only half their true level then those two figures would be doubled. Thus a company, whose premium income was expanding by 50% per annum and whose outstanding claim reserve was only half covered, would show an underwriting profit of 6% of written premium. This is greater than it should be and gives a very false impression of the profitability of the company.

If both the outstanding claim reserve and the claim payments are segregated by year of accident, then historically the adequacy of the reserve can readily be seen. Even with a new company, the extent of any under-provision would be in evidence at the time of its second report or return. There seems, therefore, to be a case for a supervisory authority asking for more frequent returns from new or fast expanding companies.

Another possible reason for a company having an apparently small reserve is reinsurance. Probably the most usual method of motor reinsurance is that of excess of loss where the reinsurer pays all the amount of the claim over and above a certain figure. As already mentioned, the larger claims are generally the claims which are settled with the longer delay; the result of this is that the excess of loss reinsurer can expect to pay an increasing proportion of the claim cost as the delay since accident increases. Once again some figures will make this plain; they are taken from the same data as Table 5.

If the excess of loss level had been £500, then the reinsurer would have had to pay 1% of the cost of claims settled in the year of accident, 6% of the cost in the following year and 38% thereafter. Thus the reserves for those claims can be similarly reduced. This would have the effect of reducing the outstanding claim reserve of 48, calculated on page 219, to 35. In practice the reinsurance level of retention would normally be much larger than £500, but this example illustrates the principle.

## LATE REPORTED CLAIMS

The outstanding claim reserve is required to cover all of the cost of claims which are outstanding at the end of the year. This should also include an allowance for the cost of accidents which have happened but which have still not been reported to the office. The average delay between accident and notification will vary according to office procedures but a month may not be unusual. Unless the company is new or expanding fast, the exclusion of such a reserve will not have a material effect upon the yearly profitability. However, with a month average delay, the reserve for these late reported claims should be one-twelfth of the year's claim cost or, in the example on page 219, 5% of premium which is just over one-tenth of the outstanding claim reserve. This could significantly alter the apparent profitability of a new company.

## CLAIMS EXPENSES

The company will have some expense in settling outstanding claims but nevertheless a special reserve is not always included. The necessary reserve may well be of the order of 5% of outstanding claim cost which is the amount which has to be included with the claim reserve in France.

## INTEREST

It is not usual to discount expected future payments for interest even though there is ample justification.

Referring to the example introduced on page 218, the outstanding payments from the 1967 accidents will be

18 in 1968
6 in 1969
6 in 1970

and discounted at 6% to the end of 1967, this would reduce the reserve from 30 to 28·21 which is a reduction of 6% which, fortuitously, is very close to the amount probably required for expenses.

## UNEXPIRED PREMIUM RESERVE

A proportion of the exposure on policies written in 1967 will not be exposed until 1968 and a reserve is required to meet the liability from this exposure. This is usually known as the unexpired premium reserve and its extent in published accounts is usually shown as a percentage (normally 40%) of the premiums written in the previous year. 40% is sufficient provided that the original premium basis was sound and the initial expenses are greater than 20%. Such a retrospective basis is clearly not acceptable for a supervisory authority without some qualification. The reserve is required to pay for

(*a*) the cost of claims arising in 1968 (or later) on policies written in 1967 (or before),
(*b*) the expenses of handling these claims, and
(*c*) the expenses of any further servicing required by any of the policies written in 1967, such as endorsements.

There are basically two alternative methods of calculating the amount of the reserve required for (*a*):

(i) unearned premiums × expected earned claim ratio, and
(ii) unearned car years × expected claim frequency × expected average claim cost

In either case a comparatively arbitrary pro rata addition will be required to cover (*b*) and (*c*). The readers of this paper who are more familiar with life assurance may find it helpful to have this problem

put into the more familiar terms of a current-cost group life assurance portfolio containing a complete variety of sums assured, which makes a reasonable parallel. The two comparable methods would then be:

$$\text{(i) unearned premiums} \times \frac{\text{1967 claims}}{\text{1967 earned premiums}}$$

(ii) unearned life-years × 1967 crude death rate × 1967 average claim

One of the advantages claimed of (ii) is that inter-office comparisons can be made but just as that could be dangerous with the crude death rate so also, and more so, would it be with the claim frequency which will vary considerably with the underwriting policy of the office and the mixture of its business. With various different levels and types of reinsurance, the average claim clearly would not be comparable either. The first method is clearly the more practical and it has the added advantage of being adaptable to other classes of business where there is no definiable unit of risk such as the car or life insured. In addition the total company reserves for all classes can be checked by it in one overall calculation. The object of a supervisory authority examining the level of reserves is to prevent any company understating them either through a genuine error or through deliberate fraud. In either event it will be preferable, other things being equal, to use the simpler statistics because there is less scope for error, and in particular, to use audited figures.

Referring again to the stable company of page 219, where the earned claims ratio was 60%,

| | | |
|---|---|---|
| the unexpired premium reserve (by method (i)) is | | |
| claim cost, 60% of unearned premiums | = ·6 × 50 = | 30 |
| claim settlement expenses, say 5% of claim cost | = ·05 × 30 = | 1·5 |
| other expenses, say 8% of unearned premiums | = ·08 × 50 = | 4 |
| Total | = | = 35·5% |

With the traditional reserve of 40%, there appears a margin of 4·5%. If the earned claims ratio had been 65% the reserve, as calculated above, becomes 38·1% and the traditional 40% is still sufficient.

Consider now a company growing at 10% a quarter (nearly 50% a

year) and with an underlying earned claims ratio of 65%. The unearned premiums are larger than the 50% used above, but are surprisingly only 53% of written premiums and the reserve as calculated above is 40·3% which is even then only just over the traditional 40%. If the expected future payments had been discounted, then even in this extreme case the traditional reserve would have been sufficient. However, this may not be said of a new company; in the first year or years 40% is then unlikely to be sufficient.

## FREE RESERVES

In addition to the reserves mentioned in the previous sections, a 'free reserve' is also required; the counterpart in a Life Office is usually called the Estate. This reserve is to safeguard a company against adverse fluctuations in experience. Clearly no reserve can be of sufficient size to give a 100% solvency guarantee but it should be large enough to make the risk of insolvency negligible. Insolvency, apart from that due to fraud, may be caused by fluctuations in any of the factors shown below or by a combination of them:

(i) the number of claims,
(ii) the cost of claims,
(iii) the value of assets and income therefrom,
(iv) the expenses of management.

Actuaries are familiar with the problems associated with the security of assets and income and this is not the place for such a discussion. Suffice here to say that the problem is there and should not be forgotten.

The fluctuations may be purely random (thus affecting companies individually), or they may be due to some basic change in the overall level of frequency or cost of claim. Random fluctuations in frequency are unlikely to cause a serious threat in motor insurance in any but the smallest companies, and reinsurance should reduce the effect of random fluctuations in the cost of claims. But with a proportion of the cost of claims not being paid out until some 2 years after the accident, which itself may well be 2 years after the level of premium was determined, there is a danger from escalating costs; in particular from those increased by legislation.

The larger the portfolio, for a given basis of reinsurance, the less

the likely effect of random fluctuations. Thus the reserve required to safeguard a company against such fluctuations need not vary directly with the level of business, which can be defined loosely by the premium income. On page 215 it is suggested that it should vary with the square root of the expected number of claims. Since the expected number of claims will be approximately proportional to the premium income, it can then be said that the reserve against random fluctuations should vary with the square root of the premium income, but this is very much tied up with the basis and extent of reinsurance. On the other hand the risk due to a basic change in experience can be expected to vary directly with the level of business and the reserve should therefore vary directly with premium income. There is then a part of the free reserve that should increase with premium income and a part that should increase with the square root of the premium income.

The more a company diversifies both into unrelated classes of business and across international boundaries, the less is the risk due to market changes. Thus, for a given size of company, the more widespread its business, the less the necessary level of reserves required to cover any market changes. It is, therefore, meaningless to think of the free reserves for a motor portfolio in one country alone in a company operating world-wide and in several classes of business. The free reserves of a company are there as a function of its whole business. Because it is not possible to quantify statistically either the risk of basic changes in the overall level of claim costs or the benefits from diversification, detailed calculations on a reserve to cover only random fluctuations will be out of place.

In the United Kingdom the required level of free reserves in non-life insurance is given by 20% of the first £2,500,000 of premiums and 10% of premiums thereafter, with an absolute minimum of £50,000.

## IV MEASURING PROFITABILITY

The underwriter's aim as mentioned is to make an underwriting profit, or, to put it another way, to produce an operating index of less than 100. The next question is what underwriting profit is required in order to pay an adequate return on capital, this being the most accepted measure of profit. In order to answer this, the balance sheet needs to be examined and Table 7 is a very simplified version of one.

The totals of the three reserves add up to more than the year's premium income but not all of this is available for investing. Of the premiums due in December, very little would have been paid before the end of the year; even November premiums could hardly have been paid because the agent's account would not go out until some time after the end of the month which leaves little time for it to be settled (this does not apply to a company writing direct). The result is that something like 25% of premiums are likely to be outstanding at any time and therefore not available for investment leaving the

Table 7

*Balance Sheet*

| | | | |
|---|---|---|---|
| Free reserves | 30 | Investments | 90 |
| Unexpired premium reserve | 40 | Outstanding premiums | 25 |
| Outstanding claim reserve | 48 | Net current assets | 3 |
| | 118 | | 118 |

Amounts are shown as percentages of the year's written premiums.

total of the investments at 90. The return on the capital employed, which is synonymous with the free reserves of 30, is thus given by:

Any underwriting profit
*Plus* the investment yield on 90
*Less* tax (based on the profit from the two above)

It is possible therefore to produce a very adequate return on capital even if there is no underwriting profit—simply because there are investments of £3 for every £1 of capital employed.

Table 8

| | Year of Payment | | | | | |
|---|---|---|---|---|---|---|
| | 1967 | 1968 | 1969 | 1970 | 1971 | *Total* |
| Premium | 750 | 250 | | | | 1,000 |
| Commission | 75 | 25 | | | | 100 |
| Expenses | 200 | 40 | | | | 240 |
| 1967 Claims } including claim payment expenses | 130 | 160 | 45 | 5 | | 340 |
| 1968 Claims } including claim payment expenses | | 230 | 80 | 25 | 5 | 340 |
| Total outgo | 405 | 455 | 125 | 30 | 5 | 1,020 |
| Underwriting loss | | | | | | 20 |

The extent to which the return will reflect the underlying experience for that year will depend upon the extent to which the opening and closing reserves are correctly valued. This is often a very confusing factor in a company analysis. The true emerging profit from 1 year's written premiums cannot be calculated exactly until the last payment is made on the resulting claims. Table 8 traces the payments that might be made from the 1967 written premiums in a private car portfolio showing an underwriting loss of 2% of premiums.

The outstanding premium of 25% is received in 1968 and the relevant commission is then paid. The expenses have been divided into three parts:

(i) 160, the cost of writing the business
(ii) 80, the cost of servicing during the policy term (40 is therefore incurred in 1968)
(iii) 32, the cost of claim settlement—these have been spread pro rata to claim cost (5%)

Total 272

The claim payments have been divided according to the year of accident and in this way illustrate the extent of the technical reserves which are required in respect of this business:

At the end of 1967

| | | | |
|---|---|---|---|
| Unexpired premium reserve | expenses | 40 | |
| | 1968 claims | 340 | (including 16 claim payment expenses) |
| | Total | 380 | |

The outstanding claim reserve $160+45+5 = 210$

At the end of 1968

Outstanding claim reserve $45+5+80+25+5 = 160$

Similarly for 1969 and 1970.

If all the income and outgo is discounted at 6% to the middle of 1967, a profit, before tax, of 11 is given and the capital employed (or free reserves) earns a return of this amount plus its own investment yield. If the free reserves are 300 the addition to this investment yield

is $3\frac{2}{3}\%$ before tax which is a very different picture from that originally painted by the underwriting loss of 2% of premium. The office aim of maximizing the return on free reserves can be translated for the underwriter into the equivalent for him—which is to maximize the return (ignoring interest and tax) on premium income. The underwriter may be given a target of perhaps breaking even which should then give a very ample return on capital though this is dependent upon:

(*a*) the yield being earned on the investments,
(*b*) the comparative sizes of free reserves and investments, and
(*c*) the underwriter's forecasts proving correct.

## V RATE MAKING

When considering changing the premium rates five questions have to be asked—and answered. Each of these is considered in turn:

(1) 'What is to be the period for which the new rates will apply?' This may seem very obvious but it is nevertheless an essential beginning. It will probably take at least 3 months from the date of the taking of a decision on new rates to the date when these rates can begin to be charged on renewals. It will then take a further year before all policies can be changed to the new basis. It may be the policy of the office not to change rates annually in which case it will be necessary to project even further ahead.

(2) 'Over this period and with the present volume and distribution of business what will be the cost of the resulting claims and expenses for the total of the portfolio?' Suppose that the present time is September 1967 and that the new rates are to apply over 1968. The resulting claims will occur over the two years 1968 and 1969; they can be regarded as a single year's claims centred at 1 January 1969. The latest available claims statistics are probably those for 1966 so these must be projected forward for $2\frac{1}{2}$ years (July 1966 to January 1969). A statistical projection based on an extrapolation of old statistics may be of limited use at a time such as this when there are so many basic changes taking place (page 208) but it nevertheless makes a useful starting-off point.

(3) 'What increase in premiums is required to pay for the increase in claims and expenses?' Compare the total expected claim and expense cost with the total premium income on the current

basis for the whole portfolio and the difference is then the extra premium required to put that business on to a profitable basis.

(4) 'Is the state of the competitive market such that this increase should be sought?' The effect of competition must always enter into any pricing decision and this is the moment. The salesman or his representatives have a vital part to play in this and the next area of rate making. Pitching new rates too high or too low is an invitation to adverse selection.

(5) 'Which sections of the portfolio should pay for the increase?' Having decided how much extra premium (if any) is required from the existing business the final and most difficult problem is deciding just which areas or sections of the account should pay for it. There are a number of different techniques which can be used to help and some of them have been referred to in the subsequent paragraphs. Above all, at the end of the exercise, it is vital to ensure that the whole increase being sought is added somewhere in the new structure.

The first step is often to apply the increase pro rata over the whole account and then to examine the rate differentials within the account. To what extent have they been sufficient in the past? This can only be done by statistically breaking down the account in as many ways as possible and examining in particular the operating index in each cell. If the data in each cell were of sufficient size for that experience to be fully representative, such that they would be likely to be repeated in subsequent years (subject only to the usual secular trends), then there would be no problem. The data would be what American Casualty Actuaries would term fully credible and a rate increase for that cell could be determined. More usually the data are less than fully credible and one has to decide to what extent to take account of the results produced; the less the data in the group the less credible they are and the more one has to ignore the results. In this 'Theory of Credibility', data are given a credibility $\lambda$, where $\lambda$ is some number less than or equal to 1 but not less than 0. If data are fully credible $\lambda = 1$, and if the data are so small that no account at all should be taken of the results then $\lambda = 0$. In motor insurance the size of $\lambda$ is determined by the number of claims and $\lambda$ generally increases with the square root of the number of claims. If the statistics in a particular section of the portfolio indicate a new premium rate of $B$ while the present rate is $A$ then the new rate is taken as $\lambda B+(1-\lambda)A = A+(B-A)\lambda$.

That is to say only a fraction of the indicated increase is taken, the fraction increasing towards unity as the data get more credible.

There are a number of ways of extracting more information from an individual cell which is not very credible and these are some:

(*a*) combine several years of data, but care should be taken because of the changing pattern of claims experience and the changing premium rates,
(*b*) pick out the very large claims and spread their cost more evenly over the portfolio, and
(*c*) examine claim frequencies or the number of claims per unit of premium income; because the underlying average size of claim does not seem to vary very much within a given portfolio the statistic claim per unit of premium income should be comparatively constant.

Any or all of these are used in practice together with anything else that might give any possible assistance.

To help in this respect some companies are currently developing a new method of statistical analysis, only made possible with the recent improvements in electronic equipment, which presents all the most recent factual information in as convenient a form as possible and very much more quickly than ever before. It overcomes three of the main problems of a traditional analysis, viz.:

(*a*) the earned premiums for any period must cover more than 1 year's business and may thereby embrace two sets of premium rates so that ratios of claims to earned premiums are not calculated on the basis of one uniform rating system,
(*b*) the use of claim estimates, which subsequently prove to be inaccurate and delay the production of statistics, and
(*c*) some of the cost of the large claims is automatically spread over the whole portfolio, thereby producing more credible results.

A necessary prerequisite of this system is to have recorded on magnetic tape (or discs): (*a*) details of the insurance position of all cars insured, which can be called the 'in force'; and (*b*) details of all claims that have been reported and amounts that have subsequently been paid on them until they are settled.

Ideally the 'in force' should be updated continuously as and when any of the statistical codes or details is altered, in practice less

frequent updating may have to be accepted. It is as well to remember that the 'in force' cannot ever represent the exact current insurance position because of the number of changes continually being made and the delays first in the policyholder reporting the change and secondly in processing the change on to the 'in force'.

Suppose statistics are required quarterly; the first step will be to make a copy of the 'in force' at the beginning and end of the quarter which can then be regarded as two censuses. The censuses are used to calculate the two statistics for any required groups:

(i) the number of car years exposed to risk during the quarter, given by $\frac{1}{8}(P_0+P_1)$ where $P_0$ and $P_1$ are, respectively, the number of cars insured at the first and second censuses,
(ii) the average premium per car insured for a year but calculated only on the policies which have been rated on the most recent premium scales.

As each claim is reported the insurance details are taken from the 'in force' so that at the end of the quarter the third statistic can be produced:

(iii) the number of claims reported; this divided by (i) gives the rate of claim which is usually expressed as a percentage, being the number of claims per 100 car years, and known as the claim frequency, and
(iv) rather than use an individual estimate of the cost of each of these claims, which is often not immediately available anyhow, the cost is estimated statistically from the distribution of the claims that have been settled during the quarter and a suitable allowance is made for inflation. This process is described on page 232.

The product of the rate of claim and the expected average claim cost give the claim cost per car year which is the necessary pure premium, assuming full credibility. An earned claims ratio is given by dividing this pure premium by (ii) above; suitable expense loadings can be added by an appropriate formula (see page 212) so that an Operating Index can be calculated which subject to credibility will provide the answer to the question: 'Is the present premium basis equitable between classes at the present rate of claim and at the present size of claim?'

Rather than use the present premium basis, provided that there is sufficient rating information coded, the actual claims experience

could be tested against a trial premium basis with the trial premiums recalculated from scratch. This new method of analysis, with such a capability, would be admirable for its flexibility and speed of output. It would also be a powerful method of analysis but it still needs a certain amount of careful handling. Among its limitations, which do not seem to be very serious, but which need to be allowed for, are that:

(*a*) the claim frequency is a frequency of claims reported which, in an expanding portfolio or class, will be an underestimate of the accident frequency,

(*b*) in an expanding portfolio or class the number of the older, and hence larger, claims is comparatively low, which may result in the average claim cost being underestimated. Since the question posed at the foot of page 231 is one concerning the relative rates between classes, neither of these last two issues matter while the whole portfolio is expanding comparatively uniformly, and

(*c*) one of the effects of increasing No Claim Discount is to cut down on the number of smaller claims; this reduces the claim frequency and increases the size of average claim. Because of the delay in claim settlement the latter effect would be apparent after the former and, as a result, a larger saving might be indicated than subsequently would be justified.

In calculating the expected average claim cost the objective is to find, from the distribution of the settled claims, the best possible estimate of the true underlying cost. Departure from any actual average introduces the possibility of distortion or bias from one group to another. It is a classical graduation problem but unlike mortality where one looks for a smoothly increasing curve there is no such ordered state. The problem is caused by the comparatively few large claims: 5·5% of the claims (those over £250) in Table 3 make up just over one-third of the total claims cost and the top 1% (over £500) cost an eighth of the whole. Some method is needed whereby the effect of these few large claims is reduced. The distribution of the logarithm of the cost of claims is approximately normal and the average of a normal distribution is usually a good estimate of its mean. So one possible method might be to take the average of the logarithms which is equivalent to the geometric mean, but this has drawbacks:

(*a*) special allowance has to be made for the zero claims,

(*b*) this certainly reduces the extent to which the odd large claim can affect the result, but is the process overdone? and
(*c*) it may be felt that, at this stage of research, this method departs too much from the practical and produces results which are difficult to interpret.

Another possible answer is to use the simple average settlement but first to spread the excess cost, over and above some figure such as £500, pro rata over all claims. This would be very simple to process and understand and it would certainly smooth the results. However, it would also introduce an element of bias in that some of the cost of accidental damage on expensive cars would be transferred to the cheaper cars.

A method adopted by some companies is a variant on that above, but instead of spreading the excess cost of all claims, only the excess cost of the third party payments is spread. There is less scope for the introduction of bias in this method because there is an element of luck (or misfortune) in the size of a third party payment. It may depend upon whether the car hits a lamp post or a gathering of well paid executives with large families. The details of such a smoothing process are:

(*a*) add up all the third party payments under each claim and total for all claims,
(*b*) deduct all third party cost in excess of £500 on any one claim,
(*c*) calculate a ratio $(1+p)$ given by:

$$1+p = \frac{\text{total third party cost}}{\text{third party cost less the excess cost from (}b\text{)}},$$

(*d*) increase all third party payments, reduced as under (*b*), by $1+p$ so that the overall total third party cost is unaltered, and
(*e*) in calculating the average cost of claim in any group, the third party payments used are those of (*d*).

This method does have a noticeable smoothing effect because although the third party payments make up only about a quarter of the total cost, they do make up some three-quarters of the cost in excess of £500 from any claim, on the basis of two samples involving some £500,000 of claims cost under private car comprehensive policies. There appears to be little scope for the introduction of bias,

it is also a simple system to operate and understand; so it satisfies most of the requirements.

There is a further possibility which is again a variant upon the simple average but which gets over its disadvantage, while at the same time it may have a greater potential smoothing effect than the method described immediately above. It is, however, less easy to understand and it is costlier to operate. Rather than have one overall level of excess, a new level of excess is calculated in each cell of each analysis such that a fixed proportion of the number of claims—say 3%—is above it. The excess in each cell above this figure is ignored and the average of the remainder is calculated. All such averages are then increased in the ratio of the overall average to the overall average with such an excess. This could operate on all the claims together, or on the Third Party and other payments separately, or on only one type of payment. The French have used a system based on this principle in a statistical analysis produced for the *Commission des Tarifs Automobile* by the *Groupement Technique Accidents.*

## EXCESSES

Over the last 18 months many companies have increased the excess which has to be paid on own damage claims when the driver is young. The effect of the introduction of such an excess is rather

Table 9

Distribution of own damage payments

| Range of payment | Cumulative percentage of payments by number | |
|---|---|---|
| | No excess | With £25 excess |
| £1– £25 | 32 | 34 |
| £26– £50 | 55 | 55 |
| £51– £75 | 69 | 69 |
| £76–£100 | 78 | 77 |
| £101–£250 | 95 | 94 |
| Over £250 | 100 | 100 |
| Average payment | £72 | £74 |

surprising. Such is the shape of the curve of the distribution of own damage payments that the introduction of excesses up to about £25 has little effect on the average payment.

Table 9 has been prepared from an examination of over 4,000

damage payments—in this context a payment means the total paid for own damage as a result of one accident. The second column was calculated from the first by ignoring the payments less than £25 and deducting £25 from the rest. The similarity between the two distributions is remarkable; the resulting average payment is slightly higher after application of the excess but 32% of the payments by number are saved. The savings to be expected by applying the £25 excess to these own damage payments represents 23% of the total claim cost. This would appear in the statistics in two ways: a reduction in claim frequency and also, probably, an increase in the proportion of zero claims. That such an excess can be expected to have such a noticeable effect on the results is yet another factor to complicate an analysis. For instance, one reason for a group of cars having a lower claim frequency than another might be that a larger proportion of them carry an excess for which they are already paying less in premium.

## KNOCK-FOR-KNOCK AGREEMENTS

Most companies in this country operate knock-for-knock agreements with each other. It is useful to consider the effect of such an agreement upon statistics. The object of the agreement is to reduce the expense of administration and negotiation in determining liability when cars with different insurers collide. The agreement covers, for the most part, vehicle damage only, and its method of operation is in brief:

(*a*) when two comprehensively insured cars collide—each insurer pays for the damage to his own car,
(*b*) when a comprehensively insured car collides with one which is not—the comprehensive insurer pays for the damage to his car, and, if found liable, would also pay for the damage to the other car; the non-comprehensive insurer would pay no vehicle damage regardless of liability, and
(*c*) the agreement does not apply when two non-comprehensively insured cars collide.

The effect of the agreement is twofold:

from (*a*) when good and bad drivers collide, under the agreement each pays his own damage in spite of the fact that the bad driver will more often be at fault. There is, therefore, a transfer of claim cost from bad drivers to good,

from (*b*) the comprehensive insurer always pays his own damage regardless of liability so there is a transfer of claim cost from non-comprehensive cover to comprehensive.

The result of these two together is that a company not operating an agreement would show a lower claim cost per car year for the good drivers with comprehensive cover. Provided that the additional cost of claims administration and negotiation does not offset this saving, that company should then be able to offer better terms for that business—and this is the class of business which is usually most sought after. The effect on non-comprehensive statistics is more startling than on comprehensive. It may well be that the claim frequency is not affected by the agreement and that its effect lies entirely in the cost per claim.

## FURTHER READING

BEARD, R. E. (1964). Some statistical problems arising from the transaction of motor insurance business. *J.S.S.* **17**, 279.

BEARD, R. E. (1967). On the compilation of non-life statistics. *J.I.A.* **93**, 271.

JOHNSON, P. D. (1968). Actuarial aspects of motor insurance. *J.S.S.* **18**, 3.

LONGLEY-COOK, L. H. An introduction to credibility theory. *P.C.A.S.* **49**, 194.

MARTIN, D. B. (1960). Automobile insurance rate-making in Canada. 16*th T.I.C.A.* **11**, 37.

STERN, P. K. Rate-making procedures for automobile liability insurance. *P.C.A.S.* **52**, 139.

There are a number of interesting and useful papers on this subject in the *Proceedings of the Casualty Actuarial Society* (*P.C.A.S.*). Many of them were reproduced in 1961 in a book printed for the C.A.S. entitled *Automobile Insurance Rate-making*.