problems in loss reserving, the researcher may here find ideas and inspiration to build upon.

The presentation of the various methods is clear and systematic, and the book represents, therefore, a valuable guide to the actuary who wants a survey of an important field of insurance mathematics.

P. LINNEMANN

Astin-groep Nederland (1982). *New Motor Rating Structure in the Netherlands Actuarial, Statistical and Market Aspects*. 128 pages

At the end of 1981, a new motor rating structure was introduced in the Netherlands, after an extensive research performed by a working group of Dutch non-life actuaries. The Dutch ASTIN Group had the excellent idea to make the results of this study available to the actuarial community.

In the introductory paper (*The Motor Insurance Market in the Netherlands*), G. W. DE WIT provides some statistical, commercial and economic background to motor car third party liability and accidental damage. In spite of the fact that the companies are free to set up their own premiums and conditions, tariffication in the Netherlands was based, industry-wide, on the following classification criteria: the catalogue value of the vehicle, the number of kilometers driven per year, the claims experience of the driver (with maximal discounts reaching 40%, or even 60%), and certain occupations. The companies gathered extensive statistical data (700 000 policies observed during one year, 80 000 claims), and appointed a study group to propose a new rating structure; one of the requirements was premium neutrality on a large scale: the premium volume had to be the same before and after the introduction of the new structure (of course on the policy-holder's level large modifications were to be expected; therefore the new structure had to be approved by the Government Insurance Board before implementation, like any premium increase).

The second paper (*Development of the Study*, by F. K. GREGORIUS) is the more important of the booklet, since it summarizes all the important steps of the study: collection of the statistical material, presentation of the methodology and of the main statistical results, construction and presentation of the new structure, modifications induced by market forces. The reading of this paper should be a "must" for any actuary interested in motorcar insurance, whether from a theoretical or a practical point of view. Indeed all compromises that had to be made between theory and practice are thoroughly explained; for instance the author is fully aware that the study group did not develop a "perfect" rating system, scientifically based in every respect. The main objective was rather to achieve an improved rating structure in the shortest possible term. First, all the possible rating factors are listed, and critically examined with respect to measurability, reliability, and usefulness. For instance, common sense and some statistical studies show that the driver's carefulness or driving skill, his nationality

and his annual mileage are among the most significant discrimination factors; however it is very difficult to introduce them in a rating structure, since (i) driving skill can hardly be measured, (ii) nationality is unlikely to be accepted in practice, as it will be considered as unfair discrimination, (iii) annual mileage is not reliable, since it is subject to fraud. Therefore one of the first tasks of the research is to replace those awkward variables by proxies, or strongly correlated variables. For example, "weight of the car" is quite a good proxy of mileage, "age of the driver" a weak proxy of driving skill.

Once the variables have been defined and the data collected, the researcher faces the important step of choosing a statistical method that selects the significant variables and combines them into a tariff. A wide range of methods is available, from the sophisticated non parametric distribution-free methods (that are the least subject to criticism, but require extensive programming) to the simple uni-dimensional approach (very elementary, but statistically unsound since it does not fully take into account the interrelationships between the explaining variables). The Dutch research group has devised its own method, a heuristic approach based mainly on a one-dimensional approach (and therefore open to some criticisms, although in the tariff construction phase, efforts were made in order to consider the interdependence of the selected variables).

The selected variables are

• the weight of the car (an original idea, since most countries use "cylinder volume" or "engine power". The three variables were considered to be of more or less equal predictive power, so weight was selected for practical purposes).

• In accidental damage the weight of the car is replaced by the catalogue value.

• Territory (3 classes, with moderate surcharges and discounts (15% and 12%))

• Use (15% surcharge if more than 20 000 km/year)

• Claims experience: a rather sophisticated bonus-malus system was devised (again, using a very crude heuristic approach); it consists of 20 classes, with premiums ranging from 40 to 160; the penalization for one claim varies from 1 to 8 classes; the starting class depends on both the age of the driver and its occupation.

The proposed tariff was however considered to be too complicated to pass the commercial test. Hence modifications were proposed, affecting principally the bonus-malus system, whose number of classes was reduced to 14.

The remaining five papers of the study each develop a special topic. H. PRINS (*Collection and Processing of Research Data*) provides insight into the way the data of the participating companies were collected, and mentions the different problems that had to be solved (homogeneity and reliability of data from different sources, I.B.N.R., corrections for knock-for-knock agreements, cost allocation between third party and accidental damage, very large claims, . . .).

In *Vehicle Dependent Rating Factors*, F. RUYGT focuses on the selection of the best car related variable, among the following ones: weight, engine power, catalogue value, year of construction, cylinder volume. Considerations of practical nature, and an analysis of loss figures by means of regression analysis justify

the decision to replace catalogue value by weight in third party liability. First it is shown that an important part of the variance of the observations remains unexplained when one uses the variables "year of construction" and "catalogue value". The regression models using "engine power" and "weight" conclude that (i) only one of those variables should be used (this is intuitively obvious), (ii) the multiple correlation coefficient is slightly better when weight is used. This result is quite surprising, since usually "engine power" is selected; although weight is unquestionably highly correlated to the claim frequency, one would have expected engine power to have the best discriminating power; indeed the prospective buyer of a car usually has several options concerning the engine; once the type and make of the car have been selected, a more powerful engine increases the car weight by only a few percentage points, but greatly influences the speed, hence the destructive power and the risk premium. One should however note that the result obtained by our Dutch colleagues relies on several assumptions:

• of course the usual assumptions of regression analysis: normality, homoskedasticity, and, above all, linearity (the analysis of the marginal means shows that this assumption could be criticized; maybe a quadratic model would provide a better fit);

• the regression analyses were performed on the averages per cell, and not on the individual observations. This certainly influences the results. In particular, one should not be surprised to observe very high multiple correlation coefficients (around 0.95! The same analysis, performed with the individual observations, would most certainly have presented correlations well below 0.10);

• the data was split into 132 cells (12 weight classes, 11 engine power classes). This completely arbitrary separation may have influenced the result.

So in order to definitely solve the question "engine power, or weight?", one should ideally apply other techniques than regression analysis; one could use non parametric models, that incorporate the split into cells in the selection procedure.

The new bonus-malus system is thoroughly analyzed by H. PRINS and F. ROOZENBOOM (Bonus-Malus). First, the importance of a posteriori rating is again stressed, and the past No Claim Bonus system is described. The very rich data collected by the companies allowed for a very detailed analysis of the claim frequencies. The authors have rightly considered that those frequencies could be used to build a system more appropriate to the Dutch situation than to apply one of the existing models of the actuarial literature. Indeed, those models use assumptions that are not quite realistic (time independent densities per insured, for instance); they do not provide any way to derive the transition rules and the number of classes; finally they do not make use of the very detailed information available to the study group. Therefore the authors have devised their own heuristic procedure, based on a simple comparison of the claim frequencies of various sub-groups.

An originality of the system is the special treatment of beginning drivers. In most countries the technically necessary higher premiums for young drivers are

obtained by a constant surcharge. Here, a much more elegant solution was found: to insert the beginners on a less advantageous step on the bonus-malus scale.

The same remark applies to the risk factor "Profession". Differences between claim frequencies of different professions were translated into differences in starting classes in the bonus-malus system. This approach is by far more satisfying than simply to introduce fixed surcharges or discounts, since everybody will be treated equitably in the long run (there are farmers who are bad risks, and professional users that provoke few accidents; the only way to treat them fairly seems to introduce different starting classes, and let the bonus-malus system do the discrimination).

In the second part of the paper the efficiency, the discriminatory power and the minimum variance bonus scale are computed for various Dutch systems (some existing ones, and the proposed one). It is shown that the proposed system is by far the best, out of all the system tested, with an efficiency around 0.3 for the most common values of the claim frequency. By computing the stationary probability distribution (i.e., the asymptotic occupational frequencies in the classes), it is shown that the proposed system should lead to a far better spread of the policies in the classes (it is well known that a major disadvantage of most existing bonus-malus systems is that after a few years most policies tend to concentrate in the best classes).

The paper by J. VAN EEGHEN, J. NIJSSEN and F. RUYGT focuses on the very important topic of *Interdependence of Risk Factors: Applications of Some Models*. 3 methods for determining rate relativities between sub-classes when a multi-dimensional classification system is used, are investigated: the well known Bailey and Simon method, and two new ones: the method of marginal totals (the premiums should exactly compensate the incurred losses in the marginal distributions), and a variant, called the direct method. Definite advantages of the last two methods are presented. Of course many other methods have been presented in the literature, and it would have been very interesting to test them all (but that would have been a formidable task).

The same three authors also provided the last contrbution: *Does a Bonus–Malus System Always Lead to a Premium Crash? A Markovian Analysis*. It is indeed well known that, in most of the existing bonus–malus systems, the concentration of the policies in the best classes after a few years of operation, produces a drastic decrease of the premium volume. The total of all bonuses is (by far) not offset by the maluses. For instance, out of a theoretical premium income of 2062 millions francs, a Belgian company has awarded (in 1981) 651 millions of bonuses, and collected only 3 millions as maluses, an implicit average premium discount of 31.4%! A premium decrease is unfortunately inevitable for commercial reasons. With average claim frequencies nowadays close to 0.1, nine claim-free years should be necessary to offset the premium increase of a single accident, if one wants a financially balanced bonus-malus system. So the penalization for a claim should be at least nine classes, and this, however justified from an actuarial point of view, is very difficult to enforce, politically and

commercially (moreover, such severe transition rules would strongly modify the claims pattern, since an enormous hunger for bonus would develop).

The calculation of the equilibrium distribution of the proposed Dutch bonus-malus system, using Markov chain theory, shows that this premium crash should not have too drastic consequences if—hopefully—economic conditions (like average claim frequency, composition of the portfolio, . . .) do not change too much: around one third of the policy-holders should ultimately find themselves in the best class.

Some considerations about the transition from the old bonus-malus system to the new one conclude this extremely interesting book.

J. LEMAIRE

J. Lemaire (1982). *L'assurance automobile*: *modèles mathématiques et statis - tiques*. 178 pages, FB 690. Bruxelles: Fernand Nathan, Editions Labor

This book on third-party automobile insurance is divided in four parts. The first part, which is non-mathematical, gives a description of the automobile insurance system in Belgium. This is also performed by means of tables with real empirical data. Furthermore, the situation in other countries is used for comparison purposes. Clearly, this first part forms a colourful introduction for the remainder of the book.

The second part addresses itself to the a priori classification of risks. It makes use of some elementary mathematics and statistics. An important topic which is discussed here is the question whether to study the number or the amount of the claims. The dependence of the average claim size on the number of claims is clearly presented and illustrated with real data. The choice and selection of explanatory dummy variables to classify the risks is discussed. This results in a linear scoring rule. This result is more or less based on the traditional assumptions of the standard linear model. The appropriateness of these assumptions for analyzing risk statistics is correctly criticised. The possibility of using generalized linear models, which pay more attention to the stochastic specification of the model, is not mentioned, however.

The third part makes more heavy use of mathematics and statistics. This part is on bonus-malus systems: the a posteriori classification of risks.

First some models for claim frequency data are presented and compared with real data. After that, a construction of an optimal bonus-malus system is given. The choice of an *optimal* system needs the specification of a loss function, as used in statistical decision theory. Various loss functions are presented and the implied behaviour of the optimal bonus-malus systems is given. Clearly, if the "optimal" bonus-malus system does not behave the way we like, something must be wrong with the specification of the loss function.

A very interesting chapter is on the possibility to take into account the severity of the claims: bonus-malus systems only utilize the number of claims, not their