

B.A.J. **8**, III, 631-637 (2002)

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ASTIN BULLETIN

Volume **32** (1), 2002

- BAIONE, F., LEVANTESI, S. & MENZEIETTI, M. *The development of an optimal bonus-malus system in a competitive market.* 159-170. BMS in force show a progressive reduction of the observed average premium, which causes a financial imbalance in the system (see Lemaire (1995)). As a consequence, frequent premium adjustments become necessary and result in a discrepancy between the reduction defined in the policy contract and the effective discount applied to the driver. Most policyholders are not aware of this 'lack of transparency'. This paper deals with the problem of designing an optimal tariff structure so that the designed BMS is adequate and satisfies both transparency and financial balance conditions.
- BUGÁR, G. & MAURER, R. *International equity portfolios and currency edging: the viewpoint of Hungarian and German insurers.* 171-197. In this paper we study the benefits derived from international diversification of equity portfolios from the German and the Hungarian points of view. In contrast to the German capital market, which is one of the largest in the world, the Hungarian Stock Exchange is an emerging market. The Hungarian stock market is highly volatile, high returns are often accompanied by extremely large risk. Therefore, there is a good potential for Hungarian investors to realise substantial benefits in terms of risk reduction by creating multi-currency portfolios. The paper gives evidence on the above mentioned benefits for both countries by examining the performance of several *ex ante* portfolio strategies. In order to control the currency risk, different types of hedging approaches are implemented.
- GUI, E. H. & MACDONALD, A. S. *A Nelson-Aalen estimate of the incidence rates of early-onset Alzheimer's disease associated with the Presenilin-1 gene.* 1-42. We analyse, in a probabilistic setting, Newcombe's (1981) life table method of estimating rates of onset of high-penetrance single-gene disorders, and extend this to a counting process model for individual life histories, including movement between risk groups arising from genetic testing and onset in relatives. A key result is that estimates of rates of onset at any age x must be conditioned only on information available when subjects were age x , even though their later life histories might be available to the investigator. This determines the data that must be included in pedigrees. We derive a Nelson-Aalen-type estimate of a function of the rate of onset, and show that when all that is known is that the persons in the study inherited a mutation with probability $1/2$, the function estimated is bounded. In practice, the treatment of censored observations or the methods of ascertainment might cause the estimate to exceed this bound, which results in infinite estimates of the rate of onset but might be a useful diagnostic check on the presence of these features. We summarise the literature on mutations in the Presenilin-1 (PSEN-1) gene, associated with early-onset Alzheimer's disease (EOAD), and from published pedigrees we estimate rates of onset of EOAD.
- HABERMAN, S. & SUNG, J.-H. *Dynamic programming approach to pension funding: the case of incomplete state information.* 129-142. Haberman and Sung (1994) have presented a dynamic model for a defined benefit occupational pension scheme which considered two types of risk: the 'contribution rate' and the 'solvency' risk. The current paper extends this work by deriving optimal funding control procedures for determining the contribution rate for the case of a

stochastic model with incomplete state information, making use of the separation principle. The stochastic inputs modelled are the investment returns and the benefit outgo.

KAAS, R., DHAENE, J., VYNCKE, D., GOOVAERTS, M. J. & DENUIT, M. *A simple geometric proof that comonotonic risks have the convex-largest sum.* 71-80. In the recent actuarial literature, several proofs have been given for the fact that if a random vector $(X_1 + X_2 + \dots + X_n)$ with given marginals has a comonotonic joint distribution, the sum $X_1 + X_2 + \dots + X_n$ is the largest possible in convex order. In this note we give a lucid proof of this fact, based on a geometric interpretation of the support of the comonotonic distribution.

LIMA, F. D. P., GARCIA, J. M. A. & DOS REIS A. D. E. *Fourier/Laplace transforms and ruin probabilities.* 91-105. In this paper we use Fourier/Laplace transforms to evaluate numerically relevant probabilities in ruin theory as an application to insurance. The transform of a function is split in two: the real and the imaginary parts. We use an inversion formula based on the real part only, to get the original function.

By using an appropriate algorithm to compute integrals and making use of the properties of these transforms we are able to compute numerically important quantities either in classical or non-classical ruin theory. As far as the classical model is concerned the problems considered have been widely studied. In what concerns the non-classical model, in particular models based on more general renewal risk processes, there is still a long way to go. In either case the approach presented is an easy method giving good approximations for reasonable values of the initial surplus.

To show this we compute numerically ruin probabilities in the classical model and in a renewal risk process in which claim inter-arrival times have an Erlang(2) distribution and compare to exact figures where available. We also consider the computation of the probability and severity of ruin in the classical model.

NG, K. W., TANG, Q. H. & YANG, H. *Maxima of sums of heavy-tailed random variables.* 43-55. In this paper, we investigate asymptotic properties of the tail probabilities of the maxima of partial sums of independent random variables. For some large classes of heavy-tailed distributions, we show that the tail probabilities of the maxima of the partial sums asymptotically equal to the sum of the tail probabilities of the individual random variables. Then we partially extend the result to the case of random sums. Applications to some commonly used risk processes are proposed. All heavy-tailed distributions involved in this paper are supposed on the whole real line.

SCHIEGL, M. *On the safety loading for chain ladder estimates: a Monte Carlo simulation study.* 107-128. A method for analysing the risk of taking a too low reserve level by the use of Chain Ladder method is developed. We give an answer to the question of how much safety loading in terms of the Chain Ladder standard error has to be added to the Chain Ladder reserve in order to reach a specified security level in loss reserving. This is an important question in the framework of integrated risk management of an insurance company. Furthermore we investigate the relative bias of Chain Ladder estimators. We use Monte Carlo simulation techniques as well as the collective model of risk theory in each cell of the run-off table. We analyse deviation between Chain Ladder reserves and Monte Carlo simulated reserves statistically. Our results document dependency on claim number and claim size distribution types and parameters.

SMYTH, G. K. & JØRGENSEN, B. *Fitting Tweedie's compound Poisson model to insurance claims data: dispersion modelling.* 143-157. We reconsider the problem of producing fair and accurate tariffs based on aggregated insurance data giving numbers of claims and total costs for the claims. Jørgensen and de Souza (SAJ, 1994) assumed Poisson arrival of claims and gamma distributed costs for individual claims. Jørgensen and de Souza (1994) directly modelled the

risk or expected costs of claims per insured unit, μ say. They observed that the dependence of the likelihood function on μ is as for a linear exponential family, so that modelling similar to that of generalized linear models is possible. In this paper we observe that, when modelling the cost of insurance claims, it is generally necessary to model the dispersion of the costs as well as their mean. In order to model the dispersion we use the framework of double generalized linear models. Modelling the dispersion increases the precision of the estimated tariffs. The use of double generalized linear models also allows us to handle the case where only the total cost of claims and not the number of claims has been recorded.

SUNDT, B. & VERNIC, R. *On error bounds for approximations to multivariate distributions II*. 57-69. In the present paper, we study error bounds for approximations to multivariate distributions. In particular, we discuss some general versions of compound multivariate distributions and look at distributions of dependent random variables constructed by linear transforms of independent random variables of vectors. Special attention is paid to the case when the support of the original distribution is restricted. We also look at some applications with multivariate Bernoulli distributions.

WANG, R. & LIU, H. *On the ruin probability under a class of risk processes*. 81-90. In this paper a class of risk processes in which claims occur as a renewal process is studied. A clear expression for Laplace transform of the finite time ruin probability is well given when the claim amount distribution is a mixed exponential. As its consequence, a well-known result about ultimate ruin probability is the classical risk model is obtained.

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NORTH AMERICAN ACTUARIAL JOURNAL

Volume 6 (2), 2002

BRENDER, A. *The use of internal models for determining liabilities and capital requirements*. 1-10. Statutory capital requirements for insurers exist in several jurisdictions. They are generally formula-based and do not reflect the specific nature of a company's asset or liability portfolio. Capital requirements for banks in the developed countries follow the Basle Capital Accord. In certain circumstances, the Accord permits the use of internal models to determine portions of a bank's required capital. The Canadian federal regulator, OSFI, is beginning to allow life insurers to use internal models for the determination of certain components of its overall capital requirement, the MCSR. This paper describes the risks that can be covered by these models and the conditions that must be satisfied before these models can be used.

FROSTIG, E. *Comparison between future lifetime distribution and its approximations*. 11-17.

GIRARD, L. N. *An approach to fair valuation of insurance liabilities using the firm's cost of capital*. 18-46. There are two competing and seemingly different methodologies for calculating fair values — the direct and indirect methods. The direct approach has the advantage of providing a more reliable assessment of the risk of financial leverage. The indirect method can

- be structured to adjust for financial leverage, however, the methodology becomes excessively complex. The advantage of the indirect method is that it can be more easily related to all exit prices. Intuitively, an exit price should reflect both the creditworthiness of the firm and the cost of capital of the firm. How are these two concepts related? This paper attempts to advance the fair valuation methodology by addressing these questions and presenting a methodology for deriving the firm or own credit risk assumption (to be used with the direct method) that is consistent with the cost of capital assumption used with the indirect method.
- GUTTERMAN, S. *The evolving role of the actuary in financial reporting of insurance*. 47-59. The demands that financial reporting of insurance companies present to actuaries are great and growing. With the prospects of change in the rules for financial reporting becoming more likely and insurance products becoming more complex, it is desirable to examine the evolving roles of the actuary and the actuarial profession. This paper describes these changes and the value that actuaries bring to financial reporting. The challenges presented are significant. As the methods of assessing and managing risk change are becoming more complex, the best efforts of the profession and individual actuaries will be needed to ensure that the actuary's role is enhanced and expanded. Not only will the techniques used evolve, but the audiences served by the actuary will become even more demanding. The actuarial profession is better situated than other professions to meet these demands.
- HABERMAN, S. & ZIMBIDIS, A. A. *An investigation of the pay-as-you-go financing method using a contingency fund and optimal control techniques*. 60-75. In many countries, aging populations are expected to lead to substantial rises in the cost of public pension systems financed by the pay-as-you-go (PAYGO) method. These systems will need to be adapted to cope with these changes. This paper considers one approach to reform, described in the literature as 'parametric' (see, e.g., Disney 2000), and develops a model for adapting the PAYGO method using a contingency fund and optimal control techniques. The solution of the original model is investigated within two different frameworks: a deterministic-continuous one and a stochastic-discrete one. Finally, a case study applied to Greece is discussed, leading to a potentially acceptable proposal of a smooth path for contribution rates and the age of eligibility for the normal retirement pension.
- MARGUS, P. *Generalized Frasier claim rates under survivorship life insurance policies*. 76-94. This paper proposes two modifications to the well-known Frasier formula, often used in the pricing, design, and valuation of survivorship life insurance policies: (1) allowing lapse rates to change after the first death and (2) reflecting simultaneous exposure to the same hazards, such as infectious diseases and common accidents, and possibly higher mortality among survivors. The purpose is to improve the pricing and valuation of survivorship life insurance. The paper will be of interest to actuaries doing pricing, GAAP valuation, self-support certifications, and to illustration actuaries. The results are important to reinsurers and direct writers. The paper includes numerical examples and compares the claim rates with and without the suggested modifications. The modified survivorship claim rates are considerably higher than those developed using pure Frasier, emphasizing the importance of learning to use these or similar methods.
- VAN BROEKHOVEN, H. *Market value of liabilities mortality risk: a practical model*. 95-106. Market values of the invested assets are frequently published. For most insurance liabilities, there are no published market values and, therefore, these have to be constructed. This construction can be based on a best estimate and a price for the risks in the liabilities. This paper presents a model explaining how the best estimate and the price of mortality risk can be constructed. Several methods to describe the risks are already known. The purpose of this paper is to describe a method to determine the mortality risk in a practical way.

WINDCLIFF, H., LE ROUX, M., FORSYTH, P. & VETZAL, K. R. *Understanding the behaviour and hedging of segregated funds offering the reset feature*. 107-124. Segregated funds have become an extremely popular Canadian investment vehicle. These instruments provide long-term maturity guarantees and often include complex option features. One controversial aspect is the reset feature, which provides the ability to lock in market gains. Recently, regulators have announced that firms offering these products will be subject to new capital requirements. This paper discusses the effects of volatility, interest rates, investor optimality, and product design on the cost of providing a segregated fund guarantee. For each scenario, the authors provide the appropriate management expense ratio (MER) that should be charged and demonstrate the current liability using a given fixed MER. The paper also investigates intuitive reasons that cause the reset feature to require such a dramatic increase in the hedging costs. Finally, an approximate method for handling the reset feature is presented that can be computed very efficiently, provided the correct proportional fee is charged.

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Society of Actuaries international symposium on living to 100 and beyond: survival at advanced ages. Florida, January 2002. <http://www.soa.org/research/living.html>

BOURBEAU, R. & DESJARDINS, B. *Dealing with problems in data quality for the measurement of mortality at advanced ages in Canada*. 1-13. The level and age trajectory of mortality at advanced ages in Canada are not readily and exactly obtained, because of problems with the reliability of data on deaths and on population counts beyond a certain point in the official statistics. There are two ways to ensure nonetheless the termination of the life tables. One consists of finding ways to validate a sufficient number of unbiased high ages at death to produce an accurate measure with the extinct, or almost extinct, generation method. This paper presents the results of a systematic verification of ages at death and a preliminary estimation of centenarian mortality based on observations, which seems to lend credence to a levelling off of mortality rates at the highest ages for females. Another is to establish convincing evidence as to the pattern of survival at the very highest ages; mathematical techniques can then be used to generate the rates as an extension of mortality at ages 70 to 90 or 100. Historical data were used here to give an insight on what this pattern of survival could be. Contrary to what might have been expected, the progression of mortality remains pretty much exponential until the unavoidable erratic values corresponding to the few extreme observations are reached. This entails that whatever the nature of the selections that would produce a slowing down of the rate of increase of the rates at the highest ages, they did not express themselves conclusively a few centuries ago.

BUETTNER, T. *Approaches and experiences in projecting mortality patterns for the oldest-old*. 14-29. In 1998 the United Nations Population Division extended the age format of its estimates and projections of population dynamics for all countries and areas of the world from 80 years and above to 100 years and above. The paper is based on experiences made during the implementation of relevant mortality projection methodologies and their application in two rounds of global population projections. The paper first briefly addresses the need for the explicit inclusion of very old population segments into the regular UN estimates and projections. It is argued that since population aging is an important issue for both developed and developing countries, the need for more information regarding the elderly, and the oldest-old in particular, is significant. The paper then documents the methods that have been evaluated and implemented, namely, the relational mortality standard proposed by Himes, Preston, and Condran, the Coale-Kisker extrapolation method for extending empirical age patterns of mortality to very high ages, and the Carter-Lee projection method for projecting

- model patterns of mortality to very high levels of life expectancy at birth. The methods are critically reviewed, and possible improvements to the methods are discussed. The paper concludes with a discussion of different views regarding the future evolution of mortality at older ages, their regional variability, and the necessity to improve the coverage and quality of data collected in this area.
- CHUEH, Y. C. M. *Efficient stochastic modeling for large and consolidated insurance business.* 88-103.
- HELD, G. *Research into the aging process: a survey.* 30-37. We are in the midst of a revolution in biological knowledge. Although research into the aging process was begun long before the Human Genome Project, it has benefited greatly from the powerful tools and techniques spun off from that endeavor. Current research is providing knowledge about life processes that may offer the prospect of slowing the aging process. Dr Francis Collins, Director of the National Human Genome Research Institute, has predicted that "By 2030, major genes responsible for the aging process in humans will likely have been identified, and clinical trials with drugs to retard the process may well be getting underway". (Collins 2000). A growing number of scientists recognize extension of the maximum life span as a possibility. The actuarial profession cannot lay claim to expertise in the area of mortality while ignoring scientific research into the causes of aging. This paper provides a brief overview of the subject and a bibliography for those interested in pursuing the matter further. It offers a brief historical perspective, a survey of current research, and a glimpse of future possibilities.
- KESTENBAUM, B. M. & FERGUSON, B. R. *Mortality of the extreme aged in the United States in the 1990s, based on improved Medicare data.* 38-44. The most extensive mortality experience of very old persons in North America is the experience reflected in the master records of Medicare enrollment. Furthermore, the data are of high quality; for example, the age in the record generally is not a mere allegation, but rather is supported by documentation. Indeed, this experience is used for the older ages in the construction of the decennial U.S. life tables. Even the best data, however, are not free of error, and the Medicare data contain errors of duplicate information, incorrect ages, and unreported deaths. These errors understandably are most serious at the oldest ages, when the true experience is least extensive. We have undertaken several initiatives at the microdata level to improve the quality of the information, and we report those initiatives and the mortality probabilities that were obtained in this paper.
- RAPPAPORT, A. M. & PARIKH, A. *Living to 100 and beyond: implications of longer life spans.* 45-53.
- ROBINE, J.-M. & VAUPEL, J. W. *Emergence of supercentarians in low-mortality countries.* 54-63.
- STALLARD, E. *Underlying and multiple cause mortality at advanced ages.* 64-87. This paper evaluates changes in cause-specific mortality for the general noninsured U.S. elderly population aged 65 years and older by sex and five-year age groups over the calendar years 1980, 1990, and 1998 for 14 leading causes of death coded according to the International Classification of Diseases (9th revision). The goals of the paper are substantive and methodological. Substantively, the goal is to assess the different contributions to the mortality decline made by diseases as underlying causes versus associated or contributing causes — as recorded in the multiple cause condition field of the death certificate. Methodologically, the goal is to introduce these data into actuarial practice and provide an initial set of tabulation methods that facilitate their use. The patterns of change over age and time of the 14 leading causes exhibited distinct characteristics in one or more of the tables presented, demonstrating

unequivocally that the diseases are neither homogeneous nor independent. This suggests that standard models such as the multiple decrement life table model that assume independent competing risks may be invalid. However, the specification of realistic and accurate alternative models will be a major challenge because of the complexity of the morbid processes involved and the requirements for data linkages that are only beginning to be developed.

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