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ASTIN BULLETIN

Volume **33** (1), 2003

CHOY, S. T. B. & CHAN, C. M. *Scale mixtures distributions in insurance applications.* 93-104. In this paper non-normal distributions via scale mixtures are introduced into insurance applications. The symmetric distributions of interest are the Student-*t* and exponential power (*EP*) distributions. A Bayesian approach is adopted with the aid of simulation to obtain posterior summaries. We shall show that the computational burden for the Bayesian calculations is alleviated via the scale mixtures representations. Illustrative examples are given.

DREKIC, S. & WILLMOT, G. E. *On the density and moments of the time of ruin with exponential claims.* 11-21. The probability density function of the time of ruin in the classical model with exponential claim sizes is obtained directly by inversion of the associated Laplace transform. This result is then used to obtain explicit closed-form expressions for the moments. The form of the density is examined for various parameter choices.

HÜRLIMANN, W. *A Gaussian exponential approximation to some compound Poisson distributions.* 41-55. A three parameter Gaussian exponential approximation to some compound Poisson distributions is considered. It is constructed by specifying the reciprocal of the mean excess function as a linear affine function below some threshold and a positive constant above this threshold. As an analytical approximation to compound distributions, it is only feasible either for a limited range of the Poisson parameter or for higher coefficients of variation. A semiparametric determination of the unknown threshold parameter is proposed. The analysis of a real-life example from pension fund mathematics displays an improved quality of fit of the new model when compared with other simple good alternative approximations based on the zero gamma, translated gamma and zero translated gamma.

PURCARU, O. & DENUIT, M. *Dependence in dynamic claim frequency credibility models.* 23-40. In nonlife insurance, actuaries usually resort to random effects to take unexpected heterogeneity into account (in the spirit of the Bühlmann–Straub model). This paper aims to study the kind of dependence induced by the introduction of correlated latent variables in the annual numbers of claims reported by policyholders. The effect of reporting claims on the *a posteriori* distribution of the random effects will be made precise. This will be done by establishing some stochastic monotonicity property of the *a posteriori* distribution with respect to the claims history.

WANG, S. S. *Equilibrium pricing transforms: new results using Buhlmann's 1980 economic model.* 57-73. In this paper we revisit an economic model of Buhlmann (ASTIN Bull., 1980) and derive equilibrium pricing transforms. We obtain the Esscher Transform and the Wang Transform under different sets of assumptions on the aggregate economic environment. We show that the Esscher Transform and the Wang Transform exhibit very different behaviours when used in pricing insurance risks.

WU, X. & WANG, J. *On characterization of distortion premium principle.* 1-10. In this paper,

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based on the additive measure integral representation of a non-additive measure integral, it is shown that any comonotonically additive premium principle can be represented as an integral of the distorted decumulative distribution function of the insurance risk. Furthermore, a sufficient and necessary condition that a premium principle is a distortion premium principle is given.

WÜTHRICH, M. V. *Asymptotic value-at-risk estimates for sums of dependent random variables.* 75-92. We estimate Value-at-Risk for sums of dependent random variables. We model multivariate dependent random variables using archimedean copulas. This structure allows one to calculate the asymptotic behaviour of extremal events. An important application of such results are Value-at-Risk estimates for sums of dependent random variables.

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Volume **9** (1), 2003

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DOBLE, A. W. *Reserves for future claims in group life portfolios.* 237-250. Group Life insurance claims for lump sum Total and Permanent Disablement benefits are substantially higher than ten years ago. This paper demonstrates that the claim reserves equal to about one year's risk premiums may now be needed for a mature portfolio of corporate superannuation policies. Delays in reporting claims are even longer under Industry Superannuation plans, causing higher reserves to be required, perhaps 150% of one year's risk premiums. Factors are suggested that group insurers may need to consider before choosing a level of reserves that is appropriate for their own blocks of business. Keywords: group life insurance, industry superannuation, claim reserve, IBNR, total and permanent disability, long tail business.

INSTITUTE OF ACTUARIES OF AUSTRALIA. *Pre-budget submission to the Commonwealth Government.* 111-190. In February 2003, the Institute of Actuaries of Australia made a pre-budget submission to the Commonwealth Government.

INSTITUTE OF ACTUARIES OF AUSTRALIA, AGEING AUSTRALIA TASKFORCE. *Submission to the House of Representatives Standing Committee on Ageing.* 191-234. In March 2003, the Institute of Actuaries of Australia made a submission to the House of Representatives Standing Committee on Ageing on the 'Inquiry into long term strategies to address the ageing of the Australian population over the next 40 years'.

INSTITUTE OF ACTUARIES OF AUSTRALIA, EXECUTIVE OPTIONS TASKFORCE. *Submission to the International Accounting Standards Board on Comments on Exposure Draft 2: Discussion Paper on Valuation of Executive and Employee Share Options.* 73-98. In February 2003, The Institute of Actuaries of Australia (IAAust) provided comments on Exposure Draft 2 'Share Based Payment' to the International Accounting Standards Board, including the Discussion Paper on Valuation of Executive and Employee Share Options by the IAAust Executive Options Taskforce.

INSTITUTE OF ACTUARIES OF AUSTRALIA, SUPERANNUATION AND OTHER EMPLOYEE BENEFITS PRACTICE COMMITTEE. *Submission to the Treasury on the portability of superannuation.* 99-110. In April 2002, the Institute of Actuaries of Australia made a submission to the Federal Treasury on the Review of the Contribution and Compulsory Cashing Standards for Superannuation. Two supplementary submissions were made in December 2002 and February 2003 on particular issues in relation to the portability of superannuation.

LEWIS, C. G. *Shaping the future: in a world of uncertainty: 2003 Presidential Address (and Discussion)* 1-50; discussion 51-70. This address looks at the profession and the Institute in a period of growth and change. It analyses the current external environment, what is happening at the moment in the various areas the profession works in, the impact of growth and change, professions and judgement, and issues relating to the legislated roles for actuaries. There is a focus on the changes the profession is currently undergoing, where that leads the profession, and what it needs to do to meet this. In terms of four key areas: The Institute and its members, Public Policy and Current Initiatives; Education and CPD; and Member Services. The address reports on current activities and initiatives and focuses on what the profession and Institute needs to do to help influence the future in a world of uncertainty, while observing that actuaries also need to adapt and change. Keywords: growth and change, public policy, professions, education, member services, international.

GENEVA PAPERS ON RISK AND INSURANCE THEORY

EICHNER, T. & WAGENER, A. *Variance vulnerability, background risks, and mean-variance preferences.* 173-184. An agent with two-parameter, mean-variance preferences is called variance vulnerable if an increase in the variance of an exogenous, independent background risk induces the agent to choose a lower level of risky activities. Variance vulnerability resembles the notion of risk vulnerability in the expected utility (EU) framework. First, we characterize variance vulnerability in terms of two-parameter utility functions. Second, we identify the multivariate normal as the only distribution such that EU- and two-parameter approach are compatible when independent background risks prevail. Third, presupposing normality, we show that — analogously to risk vulnerability — temperance is a necessary, and standardness and convex risk aversion are sufficient conditions for variance vulnerability.

KEENAN, D. C. & SNOW, A. *Locally greater vulnerability to background risk.* 161-172. Willingness to take on risk is influenced by the presence of fair and unfair background risks for decision makers who are risk vulnerable as defined by Gollier and Pratt [1996], for these decision makers are more risk averse when they possess such an uninsurable background risk. We present an alternative derivation of the index of local vulnerability based on Diamond and Stiglitz [1974] compensated increases in risk, such that risk aversion increases with the introduction of any small fair background risk if and only if the index of local vulnerability is positive. We establish that the increase in risk aversion is greater for those who are more vulnerable as measured by the index of local vulnerability.

MAHAL, A. *Will private health insurance make the distribution of public health subsidies more equal?: The case of India.* 131-160. This paper assesses the impact of the entry of private players in the health insurance market on the size of the insurance market and the distribution of public health subsidies on health care provision in India. Simulation results presented in

the paper suggest that the redistributive effect is small when richer groups have privileged access to public facilities.

PRESCOTT, E. S. *Communication in private-information models: theory and computation.* 105-130. Communication and no-communication versions of a two-stage principal-agent model are compared. The models contain a risk-averse agent and two sources of private information, a shock to preferences followed by a productive action. Both models are formulated as linear programs, which are then used to compute solutions to examples. For the communication model, an alternative method of accounting for the utility from off-equilibrium strategies is derived. This method greatly reduces the size of the linear program. For the no-communication model a Revelation-Principle like proof is provided. In simple cases, a sufficient condition for communication to be valuable is derived. In these cases, the communication improves risk-sharing in bad states of the world. In more complicated cases, computed examples demonstrate how communication may also alter labor supply. Further examples demonstrate how action and consumption lotteries may separate agents by their shock.

SCHLESINGER, H. *Some remarks on the evolution of risk preferences.* 101-104.

SINN, H.-W. *Weber's Law and the biological evolution of risk preferences: the selective dominance of the logarithmic utility function.* 87-100. The paper offers a proof that expected utility maximisation with logarithmic utility is a dominant preference in the biological selection process in the sense that a population following any other preference for decision-making under risk will, with a probability that approaches certainty, disappear relative to the population following this preference as time goes to infinity. The result is contrasted with Weber's and Fechner's Psychophysical Law which implies logarithmic sensation functions for objective physical stimuli.

INSURANCE: MATHEMATICS & ECONOMICS

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BOLANCÉ, C., GUILLÉN, M. & PINQUET, J. *Time-varying credibility for frequency risk models: estimation and tests for autoregressive specifications on the random effects.* 273-282. This paper estimates and tests autoregressive specifications for dynamic random effects in a frequency risk model. Linear credibility predictors are derived from the estimators. Examples are provided from the automobile portfolio of a Spanish insurance company.

BRITO, M. & MOREIRA FREITAS, A. C. *Limiting behaviour of a geometric-type estimator for tail indices.* 211-226. We propose a consistent estimator for the exponential tail coefficient of a d.f., that is directly related to least squares estimators of Schultze and Steinebach [Statist. Decis. 14 (1996) 353]. We investigate here the weak asymptotic properties of this geometric-type estimator, showing in particular that, under general conditions, its distribution is asymptotically normal. The results are then applied to the related problem of estimating the adjustment coefficient in risk theory [ME 10]. A simulation study is performed in order to illustrate the finite sample behaviour of the proposed estimator.

CHEN, C.-J. & PANJER, H. H. *Unifying discrete structural models and reduced-form models in credit risk using a jump-diffusion process.* 357-80. Merton [J.Finance 29] pioneered the

structural model using a diffusion process to model the firm value evolution. Since a sudden drop of firm value is impossible, Jones *et al.* [J.Finance 39] argue that the short-term yield spread and the default probability are too small. Zhou [A Jump-diffusion Approach to Modelling Credit Risk and Valuing Defaultable Securities, Federal Reserve Board, Washington, 1997] uses a jump-diffusion process that is originally proposed by Merton [J.Financial Economics 3] to model the firm value process. However, a method for finding the jump distribution is not developed. In a reduced-form model, the default probability (or intensity of default) and the mean recovery rate are obtained from the market spread by using model-specific assumptions. However, the capital structure that triggers the default usually is not used. In this paper, we propose methods to remove the discrepancy of yield spreads between structural models and reduced-form models and unify these two models. We first show the equivalence of yield spreads between structural models and reduced-form models and then find the implied jump distribution based on the market spread. The mean recovery rate for multiple seniorities and the mean recovery rate are thus obtained.

DEVOLDER, P., BOSCHE PRINCEP, M. & DOMINGUEZ FABIAN, I. *Stochastic optimal control of annuity contracts.* 227-238. The purpose of this paper is to show how stochastic optimal control theory can be applied to find an optimal investment policy before and after retirement in a defined contribution pension plan where benefits are paid under the form of annuities; annuities are supposed to be guaranteed during a certain fixed period of time. Using different kinds of utility functions we try to look at different strategies on the one hand in the investment part (i.e. before retirement) and on the other hand in the payment part (i.e. after retirement). The needed change of strategy after retirement can be interpreted in this model as a typical ALM constraint taking into account a guaranteed technical interest rate used by the insurer.

FREES, E. W. *Stochastic forecasting of labor force participation rates.* 317-336. Forecasts of labor force participation rates are important components of government projections of social insurance as well as projections of other aspects of a nation's economy. However, the current practice is to provide only deterministic projections. In contrast, this paper shows how to model the uncertainty of labor participation and provide stochastic projections.
To accommodate a wide variety of applications, labor force participation rates are highly disaggregated; this paper considers rates separated by age, sex, marital status and the presence of young children in the family. Instead of using traditional multivariate time series models, this paper introduces hierarchical and longitudinal data models to forecast labor force participation rates.
Forecasting based on longitudinal data models gives desirable results. Not only are the forecasts comparable to those produced by government projections but we can also supplement these projections with prediction intervals. These prediction intervals help users understand the forecast uncertainty, thus more completely portraying the reliability of the projections.

GENÇAY, R., SELÇUK, F. & ULUGÜLYAGCI, A. *High volatility, thick tails and extreme value theory in value-at-risk estimation.* 337-356. In this paper, the performance of the extreme value theory in value-at-risk calculations is compared to the performances of other well-known modeling techniques, such as GARCH, variance–covariance (Var–Cov) method and historical simulation in a volatile stock market. The models studied can be classified into two groups. The first group consists of GARCH(1, 1) and GARCH(1, 1)-t models which yield highly volatile quantile forecasts. The other group, consisting of historical simulation, Var–Cov approach, adaptive generalized Pareto distribution (GPD) and nonadaptive GPD models, leads to more stable quantile forecasts. The quantile forecasts of GARCH(1, 1) models are excessively volatile relative to the GPD quantile forecasts. This makes the GPD model be a robust quantile forecasting tool which is practical to implement and regulate for VaR measurements.

HOEDEMAKERS, T., BEIRLANT, J., GOOVAERTS, M. J. & DHAENE, J. *Confidence bounds for discounted loss reserves.* 297-316. In this paper we give some methods to set up confidence bounds for the *discounted* IBNR reserve. We start with a loglinear regression model and estimate the parameters by maximum likelihood such as given, for example, by Doray [Insur.: Math. Econ. 18 (1996) 43]. The knowledge of the distribution function of the discounted IBNR reserve (S) will help us to determine the initial reserve, for example, through the 95th percentile $F_S^{-1}(0.95)$. The results are based on convex order techniques, such that our approximations for the distribution function of S are larger or smaller, in convex order sense, than the true distribution function of S.

PELSSER, A. *Pricing and hedging guaranteed annuity options via static option replication.* 283-296. In this paper we derive a market value for with-profits guaranteed annuity options (GAOs) using martingale modelling techniques. Furthermore, we show how to construct a static replicating portfolio of vanilla interest rate swaptions that replicates the with-profits GAO. Finally, we illustrate with historical UK interest rate data from the period 1980 to 2000 that the static replicating portfolio would have been extremely effective as a hedge against the interest rate risk involved in the GAO, that the static replicating portfolio would have been considerably cheaper than up-front reserving and also that the replicating portfolio would have provided a much better level of protection than an up-front reserve.

RENSHAW, A. E. & HABERMAN, S. *Lee-Carter mortality forecasting with age-specific enhancements.* 255-272. We investigate the feasibility of constructing mortality forecasts on the basis of the first two sets of single value decomposition vectors, rather than just on the first such set of vectors, as in the established Lee–Carter (Gaussian) approach to mortality forecasting. Three applications are presented and the resulting forecasts compared with those constructed using two similar approaches based on generalised linear and bilinear models with Poisson error structures.

TSANAKAS, A. & BARNETT, C. *Risk capital allocation and cooperative pricing of insurance liabilities.* 239-254. The Aumann–Shapley [Values of Non-atomic Games, Princeton University Press, Princeton] value, originating in cooperative game theory, is used for the allocation of risk capital to portfolios of pooled liabilities, as proposed by Denault [Coherent allocation of risk capital, J. Risk 4]. We obtain an explicit formula for the Aumann–Shapley value, when the risk measure is given by a distortion premium principle [Axiomatic characterisation of insurance prices, IME 21]. The capital allocated to each instrument or (sub)portfolio is given as its expected value under a change of probability measure. Motivated by Mirman and Tauman [Demand compatible equitable cost sharing prices, Math. Oper. Res. 7], we discuss the role of Aumann–Shapley prices in an equilibrium context and present a simple numerical example.

VANDUFFEL, S., DHAENE, J., GOOVAERTS, M. J. & KAAS, R. *The hurdle-race problem.* 405-413. We consider the problem of how to determine the required level of the current provision in order to be able to meet a series of future deterministic payment obligations, in case the provision is invested according to a given random return process. Approximate solutions are derived, taking into account imposed minimum levels of the future random values of the reserve. The paper ends with numerical examples illustrating the presented approximations.

VERLAAK, R. & BEIRLANT, J. *Optimal reinsurance programs. An optimal combination of several reinsurance protections on a heterogeneous insurance portfolio.* 381-403. In most practical cases, the reinsurance protection of an insurance portfolio is not limited to one reinsurance type such as quota share, surplus, excess of loss or stop loss, but is organised through a combination of several methods of protection, a so-called reinsurance program.
In this paper, we will analyse optimal reinsurance programs for a given portfolio based on the "mean–variance" optimisation criterion.

Special attention is given to a description of a "surplus reinsurance" in combination with an "excess of loss per risk protection" for a heterogeneous insurance portfolio.

We derive the equations one needs to solve for finding the optimal solution for the following combinations: excess of loss after surplus, excess of loss after quota share, stop loss after quota share, quota share after stop loss, quota share after excess of loss, quota share before surplus and quota share after surplus.

It turns out that the application order of the reinsurance protections has its importance.

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JOURNAL OF RISK AND INSURANCE

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BIDDLE, J. & ROBERTS, K. *Claiming behavior in workers' compensation.* 759-780. Using administrative data on workers' compensation claims in Michigan combined with data collected from a sample of workers identified by physicians as having work-related pain in their backs, wrists, hands, or shoulders, this article provides evidence that a substantial number of potentially eligible workers do not file workers' compensation claims. Multivariate analysis identifies the effects of various factors on the probability of filing a workers' compensation claim, conditional on having a work-related health problem. We find that the severity of the worker's condition and the worker's general health are the most important determinants of the decision to file, and that the generosity of wage loss benefits also affects the decision of an eligible worker to file. Finally, claims propensities vary considerably across workplaces, holding all other measured factors constant.

BROUHNS, N., GUILLÉN, M., DENUIT, M. & PINQUET, J. *Bonus-malus scales in segmented tariffs with stochastic migration between segments.* 577-599. This article proposes a computer-intensive methodology to build bonus-malus scales in automobile insurance. The claim frequency model is taken from Pinquet, Guillén, and Bolancé (2001). It accounts for overdispersion, heteroskedasticity, and dependence among repeated observations. Explanatory variables are taken into account in the determination of the relativities, yielding an integrated automobile ratemaking scheme. In that respect, it complements the study of Taylor (1997).

DE ANDRÉS SÁNCHEZ, J. & TERCEÑO GÓMEZ, A. *Applications of fuzzy regression in actuarial analysis.* 665-699. In this article, we propose several applications of fuzzy regression techniques for actuarial problems. Our main analysis is motivated, on the one hand, by the fact that several articles in the financial and actuarial literature suggest using fuzzy numbers to model interest rate uncertainty but do not explain how to quantify these rates with fuzzy numbers. Likewise, actuarial literature has recently focused some of its attention in analyzing the Term Structure of Interest Rates (TSIR) because this is a key instrument for pricing insurance contracts. With these two ideas in mind, we show that fuzzy regression is suitable for adjusting the TSIR and discuss how to apply a fuzzy TSIR when pricing life insurance contracts and property-liability policies. Finally, we reflect on other actuarial applications of fuzzy regression and develop with this technique the London Chain Ladder Method for obtaining Incurred But Not Reported Reserves.

FEBER, D. J., FELDMEIER, J. M. & CROCKER, K. J. *The economic effects of road safety improvements: an insurance claims analysis.* 651-664. This article demonstrates the feasibility of exploiting insurance claims data to estimate the marginal benefits to society of highway

infrastructure improvements. We construct a unique database linking claims expenditures for a major auto insurer in Michigan to infrastructure investments at 62 intersections in the City of Detroit, and conclude that the addition of a left-turn lane, or left-turn phase in the signal, decreases the insurer's average monthly claims costs at a representative intersection by $944 or $1,062, respectively. The evidence also indicates that these cost savings are a result of reductions in accident severity, rather than being a consequence of fewer accidents.

HARLESS, D. W. & HOFFER, G. E. *Testing for offsetting behavior and adverse recruitment among drivers of airbag-equipped vehicles.* 629-650. Earlier studies reported that an insurance industry index of personal-injury claims rose after automobiles adopted driver's side airbags and that drivers of airbag-equipped vehicles were more likely to be at fault in fatal multivehicle accidents. These findings can be explained by the offsetting behavior hypothesis or by at-risk drivers systematically selecting vehicles with airbags (i.e. adverse recruitment). We test for offsetting behavior and adverse recruitment after airbag adoption using a database containing information on fatal accidents including information on drivers' previous records and drivers' actions that contributed to the occurrence of the accident. Further, we reexamine the personal injury claims index data for newly airbag-equipped vehicles and show that the rise in the index after airbag adoption may be attributable to moral hazard and a new vehicle ownership pattern. Rental car drivers are much more likely to commit grievous acts than other drivers, and the proportion of new automobiles in daily rental service more than doubled during the period of airbag adoption.

HARRINGTON, S. E. & TONG, Y. *Do property-casualty insurance underwriting margins have unit roots?* 715-733. A growing literature analyzes determinants of insurance prices using time series data on insurer underwriting margins. If the variables analyzed are stationary, conventional regression models may be appropriately used to test hypotheses. Based on pretests for a unit root, several studies have instead used co-integration analysis to analyze the long-run relationship between purportedly nonstationary underwriting margins and macroeconomic variables. We apply a battery of unit root tests to investigate whether underwriting margins are stationary under different assumptions concerning deterministic components in the data generating process (DGP). When linear and/or quadratic trends are included in the assumed DGPs, the tests reject the null hypothesis of a unit root for loss ratios, expense ratios, combined ratios, and economic loss ratios from 1953 through 1998 for many of the individual lines examined and for all lines combined. Consistent with prior work on whether macroeconomic variables have unit roots, a simulation of test power for underwriting margins during the sample period demonstrates that nonrejections of the null hypothesis of a unit root could easily reflect low power. The overall findings suggest that conventional regression methods can be used appropriately to analyze underwriting margins after controlling for deterministic influences and transforming any nonstationary regressors.

LAI, G. C. & LIMPAPHAYOM, P. *Organizational structure and performance: evidence from the nonlife insurance industry in Japan.* 735-757. This study examines the impact of organizational structure on firm performance, incentive problems, and financial decisions in the Japanese nonlife (property-casualty) insurance industry. Stock companies that belong to one of six horizontal keiretsu groups have lower expenses and lower levels of free cash flow than independent stock and mutual insurance companies. Keiretsu insurers also have higher profitability and higher loss ratios than independent insurers. With a limited sample size, there is some evidence that mutual insurers have higher levels of free cash flows, higher investment incomes, and lower financial leverage than their stock counterparts. Overall, empirical evidence suggests that each structure has its own comparative advantage.

PINHEIRO, P. J. R., ANDRADE, E., SILVA, J. M. & CENTENO, M. DE L. *Bootstrap methodology in claim reserving.* 701-714. In this article, we use the bootstrap technique to obtain prediction

errors for different claim-reserving methods, namely, the chain ladder technique and methods based on generalized linear models. We discuss several forms of performing the bootstrap and illustrate the different solutions using the data set from Taylor and Ashe (1983), which has already been used by several authors.

SCHMIT, J. T. & YEH, J.-H. *An economic analysis of auto compensation systems: choice experiences from New Jersey and Pennsylvania.* 601-628. Nearly since the first automobile traveled on U.S. soil, questions about how best to compensate people injured by their use have been raised. As early as in 1932, in fact, the tort system of imposing costs on negligent drivers was strongly criticized, and a system of compensation without regard to negligence recommended. Yet despite various efforts to identify and implement improved systems during the past more than 70 years, no clear best compensation mechanism has been found. Current discussions have focused on the "choice" system, under which insureds are allowed to select either a tort system or a no-fault system of compensation at the time of insurance purchase. New Jersey and Pennsylvania, which implemented very similar choice programs in 1989 and 1990, respectively, offer an opportunity to observe the effects of choice on outcomes such as: use of attorneys, speed of payment, and consistency (equity) of payment. Our results indicate outcomes consistent with expectations in New Jersey (NJ), which switched from no-fault to choice, but inconsistent with expectations in Pennsylvania (PA), which switched from tort to choice. Furthermore, analysis of tort versus no-fault selectors postchoice in New Jersey and Pennsylvania does not offer clear evidence of no-fault's lower administrative costs and speedier, more equitable payment in these jurisdictions.

COSSETTE, H., DUCHESNE, T. & MARCEAU, É. *Modeling catastrophes and their impact on insurance portfolios.* 1-22. The authors propose a general individual catastrophe risk model that allows damage ratios to be random functions of the catastrophe intensity. They derive some distributional properties of the insured risks and of the aggregate catastrophic loss under this model. Through the model and ruin probability calculations, they formally illustrate the well-known fact that the catastrophe risk cannot be diversified through premium collection alone, as is the case with the usual "day-to-day" risk, even for an arbitrary large portfolio. They also derive some risk orderings between different catastrophe portfolios and show that the risk level of a realistic portfolio falls between that of a portfolio of comonotonic risks and that of a portfolio of independent risks. Finally, the authors illustrate their findings with a numerical example inspired from earthquake insurance.

FUNG, H.-K. & LI, L. K. *Pricing discrete dynamic fund protections.* 23-31. The authors investigate the pricing of discretely monitored dynamic fund protections when the fund price follows a lognormal process or a constant elasticity of variance (CEV) process. A backward recursive pricing formula is derived. By employing a numerical technique that combines function approximation and numerical quadrature, the authors demonstrate how to complete each recursion level efficiently. Numerical experiments show that the results compare favorably with those obtained by other pricing methods.

GOOVAERTS, M. J., DE SCHEPPER, A., VYNCKE, D., DHAENE, J. & KAAS, R. *Stable laws and the present value of fixed cash flows.* 32-43. In this paper, the authors consider the present value

of a series of fixed cash flows under stochastic interest rates. To model these interest rates, they don't use the common lognormal model, but stable laws, which better fit in with reality. Their main intention is to derive a result for the distribution function of such a present value. However, due to the dependencies between successive discounted payments, the calculation of an exact analytical distribution is impossible. Therefore, use is made of the methodology of comonotonic random variables and the convex ordering of risks, introduced by the same authors in some previous papers. The present paper starts with a brief overview of properties and features of stable laws, and of the possible application of the concept of convex ordering to sums of risks, which is also the situation for a present value of future payments. Afterwards, the authors show how, for the present value under investigation, an approximation in the form of a convex upper bound can be derived. This upper bound has an easier structure than the original present value, and we derive elegant calculation formulas for the distribution of this bound. Finally, we provide some numerical examples, which illustrate the precision of the approximation. Due to the design of the present value and due to the construction of the upper bound, these illustrations show great promise concerning the accuracy of the approximation.

JONES, B. L. & ZITIKIS, R. *Empirical estimation of risk measures and related quantities.* 44-54. In this paper, we present an alternative representation of risk measures originally defined in terms of expectations with respect to distorted probabilities. We show also that the right-tail, left-tail, and two-sided deviations/indices suggested by Wang (1998) can be represented in this alternative form. Empirical estimators for these quantities are proposed, and their properties are explored.

LANDSMAN, Z. M. & VALDEZ, E. A. *Tail conditional expectations for elliptical distributions.* 55-71. Significant changes in the insurance and financial markets are giving increasing attention to the need for developing a standard framework for risk measurement. Recently, there has been growing interest among insurance and investment experts to focus on the use of a tail conditional expectation because it shares properties that are considered desirable and applicable in a variety of situations. In particular, it satisfies requirements of a "coherent" risk measure in the spirit developed by Artzner *et al.* (1999). In this paper, we derive explicit formulas for computing tail conditional expectations for elliptical distributions, a family of symmetric distributions which includes the more familiar normal and student-t distributions. We extend this investigation to multivariate elliptical distributions allowing us to model combinations of correlated risks. We are able to exploit properties of these distributions naturally permitting us to decompose the conditional expectation so that we are able to allocate contribution of individual risks to the aggregated risks. This is meaningful in practice particularly in the case of computing capital requirements for an institution who may have several lines of correlated business and is concerned of fairly allocating the total capital to these constituents.

LIN, X. S. & TAN, K. S. *Valuation of equity-indexed annuities under stochastic interest rates.* 72-91. In this paper, we consider the pricing of equity-indexed annuities (EIAs). Traditionally, the values of the guarantees embedded in these contracts are priced by modeling the underlying index fund while keeping the interest rates constant. The assumption of constant interest rates becomes unrealistic in pricing and hedging the EIAs since the embedded guaranteed are often of much longer maturity. To solve this problem, we propose an economic model which has the flexibility of modeling and underlying index fund as well as the interest rates. Some popular EIAs are illustrated to assess the implication of the proposed model.

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KALASHNIKOV, V. V. & NORBERG, R. *On the sensitivity of premiums and reserves to changes in valuation elements.* 238-256. Upon differentiating the Thiele differential equations and the equivalence condition with respect to some parameter appearing in the equations, one obtains differential equations for the derivatives of the state-wise reserves and the premium level with respect to the parameter. The solution to these equations measures the impact on premiums and reserves of a change in the parameter. Typically only numerical results can be obtained, but the method applies quite generally to multi-state policies and to virtually any parameter, and so represents a panacea in (the vast majority of) situations where analytical results are out of reach. Extensions to higher order derivatives and higher order conditional moments are straightforward. A difference method for computation is devised, and numerical results are reported for some practical cases.

MA, J. & SUN, X. *Ruin probabilities for insurance models involving investments.* 217-237. In this paper we study the ruin problem for insurance models that involve investments. Our risk reserve process is an extension of the classical Cramér-Lundberg model, which will contain stochastic interest rates, reserve-dependent expense loading, diffusion perturbed models, and many others as special cases. By introducing a new type of exponential martingale parametrized by a general rate function, we put various Cramér-Lundberg type estimations into a unified framework. We show by examples that many existing Lundberg-type bounds for ruin probabilities can be recovered by appropriately choosing the rate functions.

PAULSEN, J. & RASMUSSEN, B. N. *Simulating ruin probabilities for a class of semimartingales by importance sampling methods.* 178-216. We consider the problem of finding the probability of ruin when the risk process is assumed to be a special semimartingale with absolutely continuous characteristics. We show how the generalized Girsanov theorem can be used in connection with Monte Carlo simulation to obtain estimates of the ruin probabilities. It is shown by both analytical and numerical examples that these methods can be significantly better than ordinary simulations provided the new measure is chosen with some care.

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BLADT, M., GONZALEZ, A. & LAURITZEN, S. L. *The estimation of phase-type related functionals using Markov chain Monte Carlo methods.* 280-300. In this paper we present a method for estimation of functionals depending on one or several phase-type distributions. This could for example be the ruin probability in a risk reserve process where claims are assumed to be of phase-type. The proposed method uses a Markov chain Monte Carlo simulation to reconstruct the Markov jump processes underlying the phase-type variables in combination with Gibbs sampling to obtain a stationary sequence of phase-type probability measures from the posterior distribution of these given the observations. This enables us to find quantiles of posterior distributions of functionals of interest, thereby representing estimation uncertainty in a flexible way. We compare our estimates to those obtained by the method of maximum likelihood and find a good agreement. We illustrate the statistical potential of the method by estimating ruin probabilities in simulated examples.

COSSETTE, H., LANDRIAULT, D. & MARCEAU, É. *Ruin probabilities in the compound Markov binomial model.* 301-323. In this paper, we present a compound Markov binomial model which is an extension of the compound binomial model proposed by Gerber (1988a, b) and further examined by Shiu (1989) and Willmot (1993). The compound Markov binomial model is based

on the Markov Bernoulli process which introduces dependency between claim occurrences. Recursive formulas are provided for the computation of the ruin probabilities over finite- and infinite-time horizons. A Lundberg exponential bound is derived for the ruin probability and numerical examples are also provided.

MACDONALD, A. S. *Genetics and insurance: what have we learned so far?* 324-348. Genetics and insurance is an area unusually exposed to rapid scientific advance, close public and political scrutiny, and popular myth. It may be leading the way towards evidence-based underwriting. This survey paper describes some of the experience gained since actuarial involvement began in the mid-1990s, particularly the vital link with genetic epidemiology. We survey the relevant aims and outputs of genetic epidemiology, mainly relating to single-gene disorders, and the use of genetic epidemiology in actuarial models. The part that actuarial models might play in evidence-based approaches to underwriting and policy-making is discussed.

MILTERSEN, K. R. & PERSSON, S.-A. *Guaranteed investment contracts: distributed and undistributed excess return.* 257-279. Annual minimum rate of return guarantees are analyzed together with rules for distribution of positive excess return, i.e. investment returns in excess of the guaranteed minimum return. Together with the level of the annual minimum rate of return guarantee both the customer's and the insurer's fractions of the positive excess return are determined so that the market value of the insurer's capital inflow (determined by the fraction of the positive excess return) equals the market value of the insurer's capital outflow (determined by the minimum rate of return guarantee) at the inception of the contract. The analysis is undertaken both with and without a surplus distribution mechanism. The surplus distribution mechanism works through a bonus account that serves as a buffer in the following sense: in ('bad') years when the investment returns are lower than the minimum rate of return guarantee, funds are transferred from the bonus account to the customer's account. In ('good') years when the investment returns are above the minimum rate of return guarantee, a part of the positive excess return is credited to the bonus account. In addition to characterizations of fair combinations of the level of the annual minimum rate of return guarantee and the sharing rules of the positive excess return, our analysis indicates that the presence of a surplus distribution mechanism allows the insurer to offer a much wider menu of contracts to the customer than without a surplus distribution mechanism.

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DAVIES, N. & KIJKO, A. *Seismic risk assessment: with an application to the South African insurance industry.* 1-28. Keywords: Seismic risk, seismic hazard, expected damage, South Africa, short-term insurance.

FOROUGHI, K., JONES, I. A. & DARDIS, A. *Investment guarantees in the South African life insurance industry.* 29-75. This paper explores the risks faced by South African life insurance companies arising from the provision of investment guarantees in products sold. The current thinking and practice of the larger South African life insurance companies regarding investment guarantees is set out following their responses to a survey. The paper examines the forms of investment guarantee available and the business issues created by the writing of these guarantees. These include issues around the design and pricing of new business, as well as the risk management of in-force business. The paper also compares existing methods used internationally to value life insurance business with investment guarantees, focusing on the use of stochastic models. The different allowances for risk within each valuation method and the

appropriateness of these allowances when valuing investment guarantees are considered. The stochastic models compared include both statistically based real-world models and market-consistent state-price-deflator or risk-neutral models. Practical issues around the building of such asset-liability stochastic models are briefly discussed. Finally, the authors put forward their own views of possible developments in the future within South Africa that may impact on life insurance business with investment guarantees, and the possible implications.

McLeod, H. D., Achmar, Z. & Stein, A. M. *Minimum benefits for HIV/AIDS in South African medical schemes.* 77-111. Keywords: Medical schemes; HIV; AIDS; benefits, prescribed minimum benefits.

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