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ASTIN Bulletin

Volume 40 (1), 2010

AFONSO, L. B.; EGIDIO DOS REIS, A. D.; WATERS, H. R. *Numerical evaluation of continuous time ruin probabilities for a portfolio with credibility updated premiums.* 399-414. The probability of ruin in continuous and finite time is numerically evaluated in a classical risk process where the premium can be updated according to credibility models and therefore change from year to year. A major consideration in the development of this approach is that it should be easily applicable to large portfolios. Our method uses as a first tool the model developed by Afonso et al. (2009), which is quite flexible and allows premiums to change annually. We extend that model by introducing a credibility approach to experience rating. We consider a portfolio of risks which satisfy the assumptions of the Bühlmann (1967, 1969) or Bühlmann and Straub (1970) credibility models. We compute finite time ruin probabilities for different scenarios and compare with those when a fixed premium is considered.

ANTONIO, K.; FREES, E. W.; VALDEZ, E. A. *A multilevel analysis of intercompany claim counts.* 151-177. It is common for professional associations and regulators to combine the claims experience of several insurers into a database known as an 'intercompany' experience data set. In this paper, we analyze data on claim counts provided by the General Insurance Association of Singapore, an organization consisting of most of the general insurers in Singapore. Our data comes from the financial records of automobile insurance policies followed over a period of nine years. Because the source contains a pooled experience of several insurers, we are able to study company effects on claim behaviour, an area that has not been systematically addressed in either the insurance or the actuarial literatures. We analyze this intercompany experience using multilevel models. The multilevel nature of the data is due to: a vehicle is observed over a period of years and is insured by an insurance company under a 'fleet' policy. Fleet policies are umbrella-type policies issued to customers whose insurance covers more than a single vehicle. We investigate vehicle, fleet and company effects using various count distribution models (Poisson, negative binomial, zero-inflated and hurdle Poisson). The performance of these various models is compared; we demonstrate how our model can be used to update a priori premiums to a posteriori premiums, a common practice of experience-rated premium calculations. Through this formal model structure, we provide insights into effects that company-specific practice has on claims experience, even after controlling for vehicle and fleet effects.

BAUER, D.; BERGMANN, D.; KIESEL, R. *On the risk-neutral valuation of life insurance contracts with numerical methods in view.* 65-95. In recent years, market-consistent valuation approaches have gained an increasing importance for insurance companies. This has triggered an increasing

interest among practitioners and academics, and a number of specific studies on such valuation approaches have been published. In this paper, we present a generic model for the valuation of life insurance contracts and embedded options. Furthermore, we describe various numerical valuation approaches within our generic setup. We particularly focus on contracts containing early exercise features since these present (numerically) challenging valuation problems. Based on an example of participating life insurance contracts, we illustrate the different approaches and compare their efficiency in a simple and a generalized Black-Scholes setup, respectively. Moreover, we study the impact of the considered early exercise feature on our example contract and analyze the influence of model risk by additionally introducing an exponential Lévy model.

BAUMGARTNER, B.; GATTO, R. *A bootstrap test for the probability of ruin in the compound poisson risk process*. 241-255. In this article we propose a bootstrap test for the probability of ruin in the compound Poisson risk process. We adopt the P-value approach, which leads to a more complete assessment of the underlying risk than the probability of ruin alone. We provide second-order accurate P-values for this testing problem and consider both parametric and nonparametric estimators of the individual claim amount distribution. Simulation studies show that the suggested bootstrap P-values are very accurate and outperform their analogues based on the asymptotic normal approximation.

CHEUNG, K. C. *Optimal reinsurance revisited: a geometrical approach*. 221-239. In this paper, we reexamine the two optimal reinsurance problems studied in Cai et al. (2008), in which the objectives are to find the optimal reinsurance contracts that minimize the value-at-risk (VaR) and the conditional tail expectation (CTE) of the total risk exposure under the expectation premium principle. We provide a simpler and more transparent approach to solve these problems by using intuitive geometric arguments. The usefulness of this approach is further demonstrated by solving the VaR-minimization problem when the expectation premium principle is replaced by Wang's premium principle.

CHOO, W.; DE JONG, P. *Determining and allocating diversification benefits for a portfolio of risks*. 257-269. A critical problem in financial and insurance risk analysis is the calculation of risk margins. When there are a number of risks, the total risk margin is often reduced to reflect diversification. How large should the 'diversification benefit' be? And how should the benefit be allocated to the individual risks? We propose a simple statistical solution. While providing a theoretical analysis, the final expressions are readily implemented in practice.

COSSETTE, H.; MARCEAU, E.; MAUME-DESCHAMPS, V. *Discrete-time risk models based on time series for count random variables*. 123-150. In this paper, we consider various specifications of the general discrete-time risk model in which a serial dependence structure is introduced between the claim numbers for each period. We consider risk models based on compound distributions assuming several examples of discrete variate time series as specific temporal dependence structures: Poisson MA(1) process, Poisson AR(1) process, Markov Bernoulli process and Markov regime-switching process. In these models, we derive expressions for a function that allow us to find the Lundberg coefficient. Specific cases for which an explicit expression can be found for the Lundberg coefficient are also presented. Numerical examples are provided to illustrate different topics discussed in the paper.

DENUIT, M.; HABERMAN, S.; RENSHAW, A. E. *Comonotonic approximations to quantiles of life annuity conditional expected present values: extensions to general arima models and comparison with the bootstrap*. 331-349. This paper aims to provide accurate approximations for the quantiles of the conditional expected present value of the payments made by the annuity

provider, given the future path of the Lee-Carter time index. Conditional cohort and period life expectancies are also considered. The paper also addresses some associated simulation issues, which, hitherto, have been unresolved.

DONNELLY, C.; EMBRECHTS, P. *The devil is in the tails: Actuarial mathematics and the subprime mortgage crisis*. 1-33. In the aftermath of the 2007-2008 financial crisis, there has been criticism of mathematics and the mathematical models used by the finance industry. We answer these criticisms through a discussion of some of the actuarial models used in the pricing of credit derivatives. As an example, we focus in particular on the Gaussian copula model and its drawbacks. To put this discussion into its proper context, we give a synopsis of the financial crisis and a brief introduction to some of the common credit derivatives and highlight the difficulties in valuing some of them. We also take a closer look at the risk management issues in part of the insurance industry that came to light during the financial crisis. As a backdrop to this, we recount the events that took place at American International Group during the financial crisis. Finally, through our paper we hope to bring to the attention of a broad actuarial readership some 'lessons (to be) learned' or 'events not to be forgotten'.

FURMAN, E.; ZITIKIS, R. *General Stein-type covariance decompositions with applications to insurance and finance*. 369-375. A general 'multivariate' decomposition of covariances is formulated and proved, and its role in the context of financial risk measurement and pricing is demonstrated.

GUERRA, M.; DE LOURDES CENTENO, M. *Optimal reinsurance for variance related premium calculation principles*. 97-121. This paper deals with numerical computation of the optimal form of reinsurance from the ceding company point of view, when the cedent seeks to maximize the adjustment coefficient of the retained risk and the reinsurance loading is an increasing function of the variance. We compare the optimal treaty with the best stop loss policy. The optimal arrangement can provide a significant improvement in the adjustment coefficient when compared to the best stop loss treaty. Further, it is substantially more robust with respect to choice of the retention level than stop-loss treaties.

HASLIP, G. G.; KAISHEV, V. K. *Pricing of reinsurance contracts in the presence of catastrophe bonds*. 307-329. A methodology for pricing of reinsurance contracts in the presence of a catastrophe bond is developed. An important advantage of this approach is that it allows for the pricing of reinsurance contracts consistent with the observed market prices of catastrophe bonds on the same underlying risk process. Within the proposed methodology, an appropriate financial pricing formula is derived, under a market implied risk neutral probability measure for both a catastrophe bond and an aggregate excess of loss reinsurance contract, using a generalised Fourier transform. Efficient numerical methods for the evaluation of this formula, such as the Fast Fourier transform and Fractional Fast Fourier transform, are considered. The methodology is illustrated on several examples including Pareto and Gamma claim severities.

MACDONALD, A. S. *Survival analysis on pedigrees: A marked point process model*. 35-64. Regulation of insurers' use of genetic information means actuaries are interested in age-at-onset of genetic disorders. Arjas & Haara (1984) suggested marked point processes (MPPs) as useful models for life history data with complex covariates. Age-at-onset distributions (or equivalently, hazard rates) in respect of inherited disorders are often estimated from pedigrees, which are life histories with unusually complex covariates, as well as strong dependencies induced by

shared genes. Since Elston (1973) parametric models have often been used, conditioning the likelihood on known genotypes. However, a genotype identified by a presymptomatic genetic test is a form of internal covariate (Kalbfleisch & Prentice, 2002). We propose a very general MPP model of a pedigree, including presymptomatic genetic testing, ('the full model') and show under what circumstances the partial model leading to Elston's likelihood is valid. In practice, pedigrees are often ascertained retrospectively. Many such events can be modelled by augmenting the natural filtration of the MPP. We show that, except in simple special cases, the partial model is no longer valid, and the resulting likelihoods appear to be intractable. In particular, ascertainment interacts even with independent censoring so that likelihoods no longer factorize. For one simple special case — studies of sibships — we generalise a classical result to age-at-onset data. We conclude that the study of genetic conditions with variable age at onset gains insights from the underlying principles of survival analysis in their modern form, but that great care is needed in translating epidemiological studies into actuarial models.

MCLEISH, D. *Bounded relative error importance sampling and rare event simulation*. 377-398. We consider estimating tail events using exponential families of importance sampling distributions. When the canonical sufficient statistic for the exponential family mimics the tail behaviour of the underlying cumulative distribution function, we can achieve bounded relative error for estimating tail probabilities. Examples of rare event simulation from various distributions including Tukey's g&h distribution are provided.

MENG, H.; ZHANG, X. *Optimal risk control for the excess of loss reinsurance policies*. 179-197. The primary objective of the paper is to explore using reinsurance as a risk management tool for an insurance company. We consider an insurance company whose surplus can be modeled by a Brownian motion with drift and that the surplus can be invested in a risky or riskless asset. Under the above Black-Scholes type framework and using the objective of minimizing the ruin probability of the insurer, we formally establish that the excess-of-loss reinsurance treaty is optimal among the class of plausible reinsurance treaties. We also obtain the optimal level of retention as well as provide an explicit expression of the minimal probability of ruin.

NG, A. C. Y. *On the upcrossing and downcrossing probabilities of a dual risk model with phase-type gains*. 281-306. In this paper, we consider the dual of the classical Cramér-Lundberg model when gains follow a phase-type distribution. By using the property of phase-type distribution, two pairs of upcrossing and downcrossing barrier probabilities are derived. Explicit formulas for the expected total discounted dividends until ruin and the Laplace transform of the time of ruin under a variety of dividend strategies can then be obtained without the use of Laplace transforms.

ROSENLUND, S. *Dispersion estimates for poisson and tweedie models*. 271-279. As a consequence of pointing out an ambiguity in Renshaw (1994), we show that the Overdispersed Poisson model cannot be generated by random independent intensities. Hence Pearson's chi-square-based estimate is normally unsuitable for GLM (Generalized Linear Model) log link claim frequency analysis in insurance. We propose a new dispersion parameter estimate in the GLM Tweedie model for risk premium. This is better than the Pearson estimate, if there are sufficiently many claims in each tariff cell. Simulation results are given showing the differences between it and the Pearson estimate.

WOO, J.-K. *Some remarks on delayed renewal risk models*. 199-219. Some extensions to the delayed renewal risk models are considered. In particular, the independence assumption between

the interclaim time and the subsequent claim size is relaxed, and the classical Gerber-Shiu penalty function is generalized by incorporating more variables. As a result, general structures regarding various joint densities of ruin related quantities as well as their probabilistic interpretations are provided. The numerical example in case of time-dependent claim sizes is provided, and also the usual delayed model with time-independent claim sizes is discussed including a special case with exponential claim sizes. Furthermore, asymptotic formulas for the associated compound geometric tail for the present model are derived using two alternative methods.

WU, X.; LI, S. *Matrix-form recursions for a family of compound distributions*. 351-368.

In this paper, we aim to evaluate the distribution of the aggregate claims in the collective risk model. The claim count distribution is firstly assumed to belong to a generalised  $(a, b, 0)$  family. A matrix form recursive formula is then derived to evaluate the related compound distribution when individual claim amounts follow a discrete distribution on non-negative integers. The corresponding formula is also given for continuous individual claim amounts. Secondly, we pay particular attention to the recursive formula for compound phase-type distributions, since only certain types of discrete phase-type distributions belong to the generalised  $(a, b, 0)$  family. Similar recursive formulae are obtained for discrete and continuous individual claim amount distributions. Finally, numerical examples are presented for three counting distributions.

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#### Australian Actuarial Journal

Volume 16 (1), 2010

FERRIS, S. "*Someone else's problem*": *The failure of the Guarantee Security Life Insurance Company*. 1-64.

SERVICE, D. *The Christmas effect: Seasonal variation in disability income claim incidence and termination rates*. 65-85. The published results of analyses of experience under disability income policies rarely provide detailed analysis at yearly intervals. They normally aggregate the results of three or four years. Hence, consideration of seasonal effects has not previously been examined. However, the Institute of Actuaries of Australia has made available the raw data which underlies the published investigations made by the Institute into the experience of disability income business over the period 1980 to 2001. This raw data is sufficiently fine-grained to allow analysis of the experience by monthly intervals. As a result a detailed examination of the seasonality of claims incidence and termination has been undertaken. The results of that investigation show material seasonal variation in both claim incidence and termination which is remarkably consistent in all twenty two years of data. The disclosure of this significant seasonal variation

must add yet another piece of data in support of the proposition that disability claim experience is much more influenced by “state of mind” than “state of body”. It is not so much about ability to work – it is, rather, about the desire to work! Keywords: Disability Insurance, Claim Seasonality.

WU, X. *Ruin probabilities for a risk model with two classes of risk processes*. 87-108. In this paper a risk model with two classes of business is considered, in which claim number processes are modeled by two independent Erlang(2) processes, aiming to calculate probabilities of ruin caused by a claim from a certain class. To do so, integro-differential equations for the ruin probabilities are derived and their Laplace transforms are then obtained. At the end of this paper, numerical results for the ruin probabilities are calculated for individual claim sizes with exponential and Gamma distributions. Keywords: Erlang risk process; Integro-differential equations; Laplace transforms.

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#### Geneva Risk and Insurance Review

Volume 35 (1), 2010

BERNARD, C.; TIAN, W. *Insurance market effects of risk management metrics*. 47-80. We extend the classical analysis on optimal insurance design to the case when the insurer implements regulatory requirements (Value-at-Risk). Presumably, regulators impose some risk management requirement such as VaR to reduce the insurers' insolvency risk, as well as to improve the insurance market stability. We show that VaR requirements may better protect the insured and improve economic efficiency, but have stringent negative effects on the insurance market. Our analysis reveals that the insured are better protected in the event of greater loss irrespective of the optimal design from either the insured or the insurer perspective. However, in the presence of the VaR requirement on the insurer, the insurer's insolvency risk might be increased and there are moral hazard issues in the insurance market because the optimal contract is discontinuous.

BERTRAND, P.; PRIGENT, J.-L. *A note on risk aversion, prudence and portfolio insurance*. 81-92. This paper examines some properties of portfolio insurance that are linked to the risk aversion and the prudence of the investor. We provide explicit conditions to measure portfolio sensitivity to downside risk. We also characterize the degree of portfolio insurance by means of the ratio of absolute prudence to absolute risk aversion.

SANDMO, A. *Uncertainty in the theory of public finance*. 1-18. This paper discusses the role that the economics of uncertainty has played in the theory of public finance. From being mostly concerned with its choice-theoretic foundations in the 1950s and 1960s, the theory of expected utility maximisation and risk averse behaviour has contributed decisively to the development of several areas of the theory of public finance. Three of these have been chosen here to illustrate the general point: The theory of taxation and risk taking with focus on portfolio choice,

the role of uncertainty in public expenditure analysis (emphasising the effect of public goods provision on private risk taking) and the theory of tax evasion and compliance.

TENNYSON, S. *Incentive effects of community rating in insurance markets: evidence from Massachusetts automobile insurance*. 19-46. Rate regulations in insurance markets often impose cross-subsidies in insurance premiums from low-risk consumers to high-risk consumers. This paper develops the hypothesis that premium cross-subsidies affect risk taking by insurance consumers, and tests this hypothesis by examining the marginal impact of premium subsidies and overcharges on future insurance costs. The empirical analysis uses 1990–2003 rating cell-level data from the Massachusetts automobile insurance market, in which regulation produced large cross-subsidies across cells. Consistent with the hypothesized effects, premium subsidies are found to be significantly related to higher future insurance costs, and the opposite effects are found for premium overcharges.

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#### Insurance: Mathematics & Economics

Volume 46 (3), 2010

BERRY-STÖLZLE, T. R.; KOISSI, M.-C.; SHAPIRO, A. F. *Detecting fuzzy relationships in regression models: The case of insurer solvency surveillance in Germany*. 554-557. We develop a test for the fuzziness of regression coefficients based on the Tanaka et al. (1982) and He et al. (2007) possibilistic fuzzy regression models. We interpret the spread of the regression coefficients as a statistic measuring the fuzziness of the relationship between the corresponding independent variable and the dependent variable. We derive test distributions based on the null hypothesis that such spreads could have been obtained by estimating a possibilistic regression with data generated by a classical regression model with random errors. As an example, we show how our test detects a fuzzy regression coefficient in a solvency prediction model for German property – liability insurance companies.

BO, L.; WANG, Y.; YANG, X. *Markov-modulated jump – diffusions for currency option pricing*. 461-469. This paper introduces dynamic models for the spot foreign exchange rate with capturing both the rare events and the time-inhomogeneity in the fluctuating currency market. For the rare events, we use a compound Poisson process with log-normal jump amplitude to describe the jumps. As for the time-inhomogeneity in the market dynamics, we particularly stress the strong dependence of the domestic/foreign interest rates, the appreciation rate and the volatility of the foreign currency on the time-varying sovereign ratings in the currency market. The time-varying ratings are formulated by a continuous-time finite-state Markov chain. Based on such a spot foreign exchange rate dynamics, we then study the pricing of some currency options. Here we will adopt a so-called regime-switching Esscher transform to identify a risk-neutral martingale measure. By determining the regime-switching Esscher parameters we then get an integral expression on the prices of European-style currency options. Finally, numerical illustrations are given.

BRANGER, N.; MAHAYNI, A.; SCHNEIDER, J. C. *On the optimal design of insurance contracts with guarantees*. 485-492. The paper analyzes insurance contracts where the benefits of the

insured depend on the performance of an investment strategy and which guarantee a certain interest rate on the contributions made by the insured. The insured has to decide simultaneously on the investment strategy and the guarantee scheme. For a CRRA insured and in a BS economy, the optimal combination is given by a constant mix strategy and the contribution guarantee scheme. In case the insured has a subsistence level, the CPPI strategy turns out to be optimal for arbitrary schemes. We illustrate our results by numerical examples and analyze the utility losses of a CRRA insured due to the use of a suboptimal combination of investment strategy and guarantee scheme.

CENTENO, M. L.; GUERRA, M. *The optimal reinsurance strategy — the individual claim case.* 450-460. This paper is concerned with the optimal form of reinsurance when the cedent seeks to maximize the adjustment coefficient of the retained risk (related to the probability of ultimate ruin) – which we prove to be equivalent to maximizing the expected utility of wealth, with respect to an exponential utility with a certain coefficient of risk aversion – and restricts the reinsurance strategies to functions of the individual claims, which is the case for most nonproportional treaties placed in the market. Assuming that the premium calculation principle is a convex functional we prove the existence and uniqueness of solutions and provide a necessary optimality condition (via needle-like perturbations, widely known in optimal control). These results are used to find the optimal reinsurance policy when the reinsurance loading is increasing with the variance. The optimal contract is described by a nonlinear function, of a similar form than in the aggregate case.

DEGEN, M.; LAMBRIGGER, D. D.; SEGERS, J. *Risk concentration and diversification: Second-order properties.* 541-546. The quantification of diversification benefits due to risk aggregation plays a prominent role in the (regulatory) capital management of large firms within the financial industry. However, the complexity of today's risk landscape makes a quantifiable reduction of risk concentration a challenging task. In the present paper we discuss some of the issues that may arise. The theory of second-order regular variation and second-order subexponentiality provides the ideal methodological framework to derive second-order approximations for the risk concentration and the diversification benefit.

GAO, J. *An extended CEV model and the Legendre transform–dual–asymptotic solutions for annuity contracts.* 511-530. This paper develops an extended constant elasticity of variance (E-CEV) model to overcome the shortcomings of the general CEV model. Under the E-CEV model, we study the optimal investment strategy before and after retirement in a defined contribution pension plan where benefits are paid by annuity. By applying the Legendre transform, dual theory and an asymptotic expansion approach, we respectively derive two asymptotic strategies for a CRRA and CARA utility functions in two different periods. Furthermore, we find that each asymptotic strategy can be decomposed into an optimal zero-order strategy and a perturbation strategy. The optimal zero-order strategy denotes an investment strategy where the current volatility is just equal to the mean level of the volatility, whereas the perturbation strategy provides an approximation solution to hedge the slow varying nature of the current volatility deviating from mean level. Finally, we find that the optimal zero-order strategy under given conditions will reduce to the results of Devolder et al. (2003), Xiao et al. (2007) and Gao (2009), respectively.

GU, M.; YANG, Y.; LI, S.; ZHANG, J. *Constant elasticity of variance model for proportional reinsurance and investment strategies.* 580-587. In our model, the insurer is allowed to buy reinsurance and invest in a risk-free asset and a risky asset. The claim process is assumed to follow a Brownian motion with drift, while the price process of the risky asset is described by the

constant elasticity of variance (CEV) model. The Hamilton-Jacobi-Bellman (HJB) equation associated with the optimal reinsurance and investment strategies is established, and solutions are found for insurers with CRRA or CARRA utility.

HAINAUT, D. *Optimal design of profit sharing rates by FFT*. 470-478. This paper addresses the calculation of a fair profit sharing rate for participating policies with a minimum interest rate guaranteed. The bonus credited to policies depends on the performance of a basket of two assets: a stock and a zero coupon bond and on the guarantee. The dynamics of the instantaneous short rates are driven by a Hull and White model, whereas the stocks follow a double exponential jump-diffusion model. The participation level is determined such that the return retained by the insurer is sufficient to hedge the interest rate guaranteed. Given that the return of the total asset is not lognormal, we rely on a Fast Fourier Transform to compute the fair value of bonus and guarantee options.

HE, L.; YANG, X. *The compound binomial model with randomly paying dividends to shareholders and policyholders*. 443-449. Considering surplus of a joint stock insurance company based on compound binomial model, set up thresholds  $a_1$ ,  $a_2$  for shareholders and policyholders respectively. When surplus is no less than the thresholds, the company randomly pays dividends to shareholders and policyholders with probabilities  $q_1$ ,  $q_2$  respectively. For this model, we have derived the recursive formulas of both the expected discount penalty function and ruin probability, and the distribution function of the deficit at ruin.

LANDSMAN, Z. *On the Tail Mean-Variance optimal portfolio selection*. 547-553. In the present paper we propose the Tail Mean – Variance (TMV) approach, based on Tail Condition Expectation (TCE) (or Expected Short Fall) and the recently introduced Tail Variance (TV) as a measure for the optimal portfolio selection. We show that, when the underlying distribution is multivariate normal, the TMV model reduces to a more complicated functional than the quadratic and represents a combination of linear, square root of quadratic and quadratic functionals. We show, however, that under general linear constraints, the solution of the optimization problem still exists and in the case where short selling is possible we provide an analytical closed form solution, which looks more “robust” than the classical MV solution. The results are extended to more general multivariate elliptical distributions of risks.

MERZ, M.; WÜTHRICH, M. V. *Paid-incurred chain claims reserving method*. 568-579.

We present a novel stochastic model for claims reserving that allows us to combine claims payments and incurred losses information. The main idea is to combine two claims reserving models (Hertig’s (1985) model and Gogol’s (1993) model) leading to a log-normal paid – incurred chain (PIC) model. Using a Bayesian point of view for the parameter modelling we derive in this Bayesian PIC model the full predictive distribution of the outstanding loss liabilities. On the one hand, this allows for an analytical calculation of the claims reserves and the corresponding conditional mean square error of prediction. On the other hand, simulation algorithms provide any other statistics and risk measure on these claims reserves.

PERERA, R. S. *Optimal consumption, investment and insurance with insurable risk for an investor in a Lévy market*. 479-484. Numerous researchers have applied the martingale approach for models driven by Lévy processes to study optimal investment problems. The aim of this paper is to apply the martingale approach to obtain a closed form solution for the optimal investment, consumption and insurance strategies of an individual in the presence of an insurable risk when

the insurable risk and risky asset returns are described by Lévy processes and the utility is a constant absolute risk aversion (CARA). The model developed in this paper can potentially be applied to absorb large insurable losses in the absence of insurance protection and to examine the level of diminishing current utility and consumption.

SU, K. C. *The conversion option in life insurance*. 437-442. This paper introduces an option that has been provided by life insurance companies extensively but has not been discussed in much in the literature; the conversion option. By constructing a valuation model, we first confirm that the conversion option may have positive values. We further find that the value of this option highly depends on the difference of the expected and actual mortality pattern after the insured individual converts his/her policy. Meanwhile, considering the general trend of mortality improvement, we incorporate this trend by applying the Lee-Carter model, hoping to provide a reasonable and fair valuation of the conversion option.

VAN LAERE, E.; BAESENS, B. *The development of a simple and intuitive rating system under Solvency II*. 500-510. Regulatory authorities pay considerable attention to setting minimum capital levels for different kinds of financial institutions. Solvency II, the European Commission's planned reform of the regulation of insurance companies is well underway. One of its consequences will be a shift in focus to internally based models in determining the regulatory capital needed to cover unexpected losses. This evolution emphasises the importance of credit risk assessment through internal ratings. In light of this new prudential regulation, this paper suggests a Basel II compliant approach to predicting credit ratings for non-rated corporations and evaluates its performance compared to external ratings. The paper provides an interesting modelling of non-financial European companies rated by S&P. In developing the model, broad applicability is set as an important boundary condition. Even though the model developed is fairly simple and maintains a high level of granularity, it gives high rates of accuracy and is very interpretable.

ZHANG, W.-G.; ZHANG, X.-L.; XU, W.-J. *A risk tolerance model for portfolio adjusting problem with transaction costs based on possibilistic moments*. 493-499. Due to changes of situation in financial markets and investors' preferences towards risk, an existing portfolio may not be efficient after a period of time. In this paper, we propose a possibilistic risk tolerance model for the portfolio adjusting problem based on possibility moments theory. A Sequential Minimal Optimization (SMO)-type decomposition method is developed for finding exact optimal portfolio policy without extra matrix storage. We present a simple method to estimate the possibility distributions for the returns of assets. A numerical example is provided to illustrate the effectiveness of the proposed models and approaches.

ZHANG, Y. *A general multivariate chain ladder model*. 588-599. A general multivariate stochastic reserving model is formulated, which not only specifies contemporaneous correlations, but also allows structural connections among triangles. Its structure extends the existing multivariate chain ladder models in a natural way, and this extension proves to be advantageous in improving model adequacy and increasing model flexibility. It is general in the sense that it includes various models in the chain ladder framework as special cases. At the heart of this model is the seemingly unrelated regression technique, which is utilized to estimate parameters that reflect contemporaneous correlations. The use of this technique is essential to construct flexible models, and related statistical theories are applied to study properties of existing estimators. A numerical example is utilized to show the advantage of the proposed model in studying multiple triangles that are related both structurally and contemporaneously.

ZHOU, C. *Dependence structure of risk factors and diversification effects*. 531-540. In this paper, we study the aggregated risk from dependent risk factors under the multivariate Extreme Value Theory (EVT) framework. We consider the heavy-tailedness of the risk factors as well as the non-parametric tail dependence structure. This allows a large range of models on the dependence. We assess the Value-at-Risk of a diversified portfolio constructed from dependent risk factors. Moreover, we examine the diversification effects under this setup.

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### Insurance: Mathematics & Economics

Volume 47 (1), 2010

DATE, P.; MAMON, R.; JALEN, L.; WANG, I. C. *A linear algebraic method for pricing temporary life annuities and insurance policies*. 98-104. We recast the valuation of annuities and life insurance contracts under mortality and interest rates, both of which are stochastic, as a problem of solving a system of linear equations with random perturbations. A sequence of uniform approximations is developed which allows for fast and accurate computation of expected values. Our reformulation of the valuation problem provides a general framework which can be employed to find insurance premiums and annuity values covering a wide class of stochastic models for mortality and interest rate processes. The proposed approach provides a computationally efficient alternative to Monte Carlo based valuation in pricing mortality-linked contingent claims.

DIMITROVA, D. S.; KAISHEV, V. K. *Optimal joint survival reinsurance: An efficient frontier approach*. 27-35. The problem of optimal excess of loss reinsurance with a limiting and a retention level is considered. It is demonstrated that this problem can be solved, combining specific risk and performance measures, under some relatively general assumptions for the risk model, under which the premium income is modelled by any non-negative, non-decreasing function, claim arrivals follow a Poisson process and claim amounts are modelled by any continuous joint distribution. As a performance measure, we define the expected profits at time  $x$  of the direct insurer and the reinsurer, given their joint survival up to  $x$ , and derive explicit expressions for their numerical evaluation. The probability of joint survival of the direct insurer and the reinsurer up to the finite time horizon  $x$  is employed as a risk measure. An efficient frontier type approach to setting the limiting and the retention levels, based on the probability of joint survival considered as a risk measure and on the expected profit given joint survival, considered as a performance measure is introduced. Several optimality problems are defined and their solutions are illustrated numerically on several examples of appropriate claim amount distributions, both for the case of dependent and independent claim severities.

FROSTIG, E. *Asymptotic analysis of a risk process with high dividend barrier*. 21-26. In this paper we study a risk model with constant high dividend barrier. We apply Keilson's (1966) results to the asymptotic distribution of the time until occurrence of a rare event in a regenerative process, and then results of the cycle maxima for random walk to obtain the asymptotic distribution of the time to ruin and the amount of dividends paid until ruin.

KOJADINOVICA, I.; YAN, J. *Comparison of three semiparametric methods for estimating dependence parameters in copula models.* 52-63. Three semiparametric methods for estimating dependence parameters in copula models are compared, namely maximum pseudo-likelihood estimation and the two method-of-moment approaches based on the inversion of Spearman's rho and Kendall's tau. For each of these three asymptotically normal estimators, an estimator of their asymptotic (co)variance is stated in three different situations, namely the bivariate one-parameter case, the multivariate one-parameter case and the multivariate multiparameter case. An extensive Monte Carlo study is carried out to compare the finite-sample performance of the three estimators under consideration in these three situations. In the one-parameter case, it involves up to six bivariate and four-variate copula families, and up to five levels of dependence. In the multiparameter case, attention is restricted to trivariate and four-variate normal and t copulas. The maximum pseudo-likelihood estimator appears as the best choice in terms of mean square error in all situations except for small and weakly dependent samples. It is followed by the method-of-moment estimator based on Kendall's tau, which overall appears to be significantly better than its analogue based on Spearman's rho. The simulation results are complemented by asymptotic relative efficiency calculations. The numerical computation of Spearman's rho, Kendall's tau and their derivatives in the case of copula families for which explicit expressions are not available is also investigated.

LEFÈVRE, C.; GATHY, M. *On the Lagrangian Katz family of distributions as a claim frequency model.* 76-83. The Panjer (Katz) family of distributions is defined by a particular first-order recursion which is built on the basis of two parameters. It is known to characterize the Poisson, negative binomial and binomial distributions. In insurance, its main usefulness is to yield a simple recursive algorithm for the aggregate claims distribution. The present paper is concerned with the more general Lagrangian Katz family of distributions. That family satisfies an extended recursion which now depends on three parameters. To begin with, this recursion is derived through a certain first-crossing problem and two applications in risk theory are described. The distributions covered by the recursion are then identified as the generalized Poisson, generalized negative binomial and binomial distributions. A few other properties of the family are pointed out, including the index of dispersion, an extended Panjer algorithm for compound sums and the asymptotic tail behaviour. Finally, the relevance of the family is illustrated with several data sets on the frequency of car accidents.

LEFÈVRE, C.; LOISEL, S. *Stationary-excess operator and convex stochastic orders.* 64-75. The present paper aims to point out how the stationary-excess operator and its iterates transform s-convex stochastic orders and the associated moment spaces. This allows us to propose a new unified method on constructing s-convex extrema for distributions that are known to be t-monotone. Both discrete and continuous cases are investigated. Several extremal distributions under monotonicity conditions are derived. They are illustrated with some applications in insurance.

LIN, J.-G.; HUANG, C.; ZHU, L.-P. *Estimating generalized state density of near-extreme events and its applications in analyzing stock data.* 13-20. This paper studies the generalized state density (GDOS) of near-historical extreme events of a set of independent and identically distributed (i.i.d.) random variables. The generalized density of states is proposed which is defined as a probability density function (p.d.f.). For the underlying distribution in the domain of attraction of the three well-known extreme value distribution families, we show the approximate form of the mean GDOS. Estimates of the mean GDOS are presented when the underlying

distribution is unknown and the sample size is sufficiently large. Some simulations have been performed, which are found to agree with the theoretical results. The closing price data of the Dow-Jones industrial index are used to illustrate the obtained results.

MAYORAL, S.; GZYL, H. *A method for determining risk aversion functions from uncertain market prices of risk*. 84-89. In Gzyl and Mayoral (2008) we developed a technique to solve the following type of problems: How to determine a risk aversion function equivalent to pricing a risk with a load, or equivalent to pricing different risks by means of the same risk distortion function. The information on which the procedure is based consists of the market prices of the risk. Here we extend that method to cover the case in which there may be uncertainties in the market prices of the risks.

PENG, L.; LIM, A. E. B.; SHANTHIKUMAR, J. G. *Optimal risk transfer for agents with germs*. 1-12. We introduce a new class of risk measures called generalized entropic risk measures (GERMS) that allow economic agents to have different attitudes towards different sources of risk. We formulate the problem of optimal risk transfer in terms of these risk measures and characterize the optimal transfer contract. The optimal contract involves what we call intertemporal source-dependent quotient sharing, where agents linearly share changes in the aggregate risk reserve that occur in response to shocks to the system over time, with scaling coefficients that depend on the attitudes of each agent towards the source of risk causing the shock. Generalized entropic risk measures are not dilations of a common base risk measure, so our results extend the class of risk measures for which explicit characterizations of the optimal transfer contract can be found.

PETERS, G. W.; WÜTHRICH, M. V.; SHEVCHENKO, P. V. *Chain ladder method: Bayesian bootstrap versus classical bootstrap*. 36-51. The intention of this paper is to estimate a Bayesian distribution-free chain ladder (DFCL) model using approximate Bayesian computation (ABC) methodology. We demonstrate how to estimate quantities of interest in claims reserving and compare the estimates to those obtained from classical and credibility approaches. In this context, a novel numerical procedure utilizing a Markov chain Monte Carlo (MCMC) technique, ABC and a Bayesian bootstrap procedure was developed in a truly distribution-free setting. The ABC methodology arises because we work in a distribution-free setting in which we make no parametric assumptions, meaning we cannot evaluate the likelihood point-wise or in this case simulate directly from the likelihood model. The use of a bootstrap procedure allows us to generate samples from the intractable likelihood without the requirement of distributional assumptions; this is crucial to the ABC framework. The developed methodology is used to obtain the empirical distribution of the DFCL model parameters and the predictive distribution of the outstanding loss liabilities conditional on the observed claims. We then estimate predictive Bayesian capital estimates, the value at risk (VaR) and the mean square error of prediction (MSEP). The latter is compared with the classical bootstrap and credibility methods.

VAN WEERT, K.; DHAENE, J.; GOOVAERTS, M. *Optimal portfolio selection for general provisioning and terminal wealth problems*. 90-97. In Dhaene et al. (2005), multiperiod portfolio selection problems are discussed, using an analytical approach to find optimal constant mix investment strategies in a provisioning or a savings context. In this paper we extend some of these results, investigating some specific, real-life situations. The problems that we consider in the first section of this paper are general in the sense that they allow for liabilities that can be both positive or negative, as opposed to Dhaene et al. (2005), where all liabilities have to be of the same sign. Secondly, we generalize portfolio selection problems to the case where a minimal return

requirement is imposed. We derive an intuitive formula that can be used in provisioning and terminal wealth problems as a constraint on the admissible investment portfolios, in order to guarantee a minimal annualized return. We apply our results to optimal portfolio selection.

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APAYDIN, A.; BASER, F. *Hybrid fuzzy least-squares regression analysis in claims reserving with geometric separation method*. 113-122. Claims reserving is obviously necessary for representing future obligations of an insurance company and selection of an accurate method is a major component of the overall claims reserving process. However, the wide range of unquantifiable factors which increase the uncertainty should be considered when using any method to estimate the amount of outstanding claims based on past data. Unlike traditional methods in claims analysis, fuzzy set approaches can tolerate imprecision and uncertainty without loss of performance and effectiveness. In this paper, hybrid fuzzy least-squares regression, which is proposed by Chang (2001), is used to predict future claim costs by utilizing the concept of a geometric separation method. We use probabilistic confidence limits for designing triangular fuzzy numbers. Thus, it allows us to reflect variability measures contained in a data set in the prediction of future claim costs. We also propose weighted functions of fuzzy numbers as a defuzzification procedure in order to transform estimated fuzzy claim costs into a crisp real equivalent.

CHEN, S.; LI, Z.; LI, K. *Optimal investment–reinsurance policy for an insurance company with VaR constraint*. 144-153. This paper investigates an investment–reinsurance problem for an insurance company that has a possibility to choose among different business activities, including reinsurance/new business and security investment. Our main objective is to find the optimal policy to minimize its probability of ruin. The main novelty of this paper is the introduction of a dynamic Value-at-Risk (VaR) constraint. This provides a way to control risk and to fulfill the requirement of regulators on market risk. This problem is formulated as an infinite horizontal stochastic control problem with a constrained control space. The dynamic programming technique is applied to derive the Hamilton–Jacobi–Bellman (HJB) equation and the Lagrange multiplier method is used to tackle the dynamic VaR constraint. Closed-form expressions for the minimal ruin probability as well as the optimal investment–reinsurance/new business policy are derived. It turns out that the risk exposure of the insurance company subject to the dynamic VaR constraint is always lower than otherwise. Finally, a numerical example is given to illustrate our results.

CHEUNG, K. C. *Characterizing a comonotonic random vector by the distribution of the sum of its components*. 130-136. In this article, we characterize comonotonicity and related dependence structures among several random variables by the distribution of their sum. First we prove that if the sum has the same distribution as the corresponding comonotonic sum, then the underlying random variables must be comonotonic as long as each of them is integrable. In the literature, this result is only known to be true if either each random variable is square integrable or possesses a continuous distribution function. We then study the situation when the distribution of the sum

only coincides with the corresponding comonotonic sum in the tail. This leads to the dependence structure known as tail comonotonicity. Finally, by establishing some new results concerning convex order, we show that comonotonicity can also be characterized by expected utility and distortion risk measures.

CHEUNG, K. C. *Comonotonic convex upper bound and majorization*. 154-158. When the dependence structure among several risks is unknown, it is common in the actuarial literature to study the worst dependence structure that gives rise to the riskiest aggregate loss. A central result is that the aggregate loss is the riskiest with respect to convex order when the underlying risks are comonotonic. Many proofs were given before. The objective of this article is to present a new proof using the notions of decreasing rearrangement and the majorization theorem, and give clear explanation of the relation between convex order, the theory of majorization and comonotonicity.

CHRISTIANSEN, M. C. *Biometric worst-case scenarios for multi-state life insurance policies*. 190-197. It is common actuarial practice to calculate premiums and reserves under a set of biometric assumptions that represent a worst-case scenario for the insurer. The new solvency regime of the European Union (Solvency II) also uses worst-case scenarios for the calculation of solvency capital requirements for life insurance business. Surprisingly, the actuarial literature so far offers no exact method for the construction of biometric scenarios that let premiums and reserves be always on the safe side with respect to a given confidence band for the biometric second-order basis. The present paper partly fills this gap by introducing a general method that allows one to construct such scenarios for homogenous portfolios of life insurance policies. The results are especially informative for life insurance policies with mixed character (e.g. survival and occurrence character). Two examples are given that illustrate the new method, demonstrate its usefulness for the calculation of premiums and reserves, and show how the new approach could improve the calculation of biometric solvency reserves for Solvency II.

DONG, J.; YANG, H.; CHEUNG, K. C. *Upper comonotonicity and convex upper bounds for sums of random variables*. 159-166. It is well-known that if a random vector with given marginal distributions is comonotonic, it has the largest sum with respect to convex order. However, replacing the (unknown) copula by the comonotonic copula will in most cases not reflect reality well. For instance, in an insurance context we may have partial information about the dependence structure of different risks in the lower tail. In this paper, we extend the aforementioned result, using the concept of upper comonotonicity, to the case where the dependence structure of a random vector in the lower tail is already known. Since upper comonotonic random vectors have comonotonic behavior in the upper tail, we are able to extend several well-known results of comonotonicity to upper comonotonicity. As an application, we construct different increasing convex upper bounds for sums of random variables and compare these bounds in terms of increasing convex order.

ESMAEILI, H.; KLÜPPELBERG, C. *Parameter estimation of a bivariate compound Poisson process*. 224-233. In this article, we review the concept of a Lévy copula to describe the dependence structure of a bivariate compound Poisson process. In this first statistical approach we consider a parametric model for the Lévy copula and estimate the parameters of the full dependent model based on a maximum likelihood approach. This approach ensures that the estimated model remains in the class of multivariate compound Poisson processes. A simulation study investigates the small sample behaviour of the MLEs, where we also suggest a new simulation algorithm. Finally, we apply our method to Danish fire insurance data.

GERBER, H. U.; YANG, H. *Obtaining the dividends–penalty identities by interpretation*. 206-207.

The dividends–penalty identity is a relation between three functions: the discounted penalty function without dividends, the discounted penalty function if a barrier dividend strategy is applied, and the expected discounted dividends until ruin. The classical model of risk theory is modified in that the deterministic premiums are replaced by a compound Poisson process with exponential jumps. In this model, the dividends–penalty identity is new and can be derived by interpretation. Then the dividends–penalty identity in the classical model is obtained as a limit.

GOOVAERTS, M. J.; KAAS, R.; LAEVEN, R. J. A. *A note on additive risk measures in rank-dependent utility*. 187-189. This note proves that risk measures obtained by applying the equivalent utility principle in rank-dependent utility are additive if and only if the utility function is linear or exponential and the probability weighting (distortion) function is the identity.

HIPP, C.; TAKSAR, M. *Optimal non-proportional reinsurance control*. 246-254. This paper deals with the problem of ruin probability minimization under various investment control and reinsurance schemes. We first look at the minimization of ruin probabilities in the models in which the surplus process is a continuous diffusion process in which we employ stochastic control to find the optimal policies for reinsurance and investment. We then focus on the case in which the surplus process is modelled via a classical Lundberg process, i.e. the claims process is compound Poisson. There, the optimal reinsurance policy is derived from the Hamilton–Jacobi–Bellman equation.

HUANG, J.; WANG, G.; WU, Z. *Optimal premium policy of an insurance firm: Full and partial information*. 208-215. Herein, we study the optimization problem faced by an insurance firm who can control its cash-balance dynamics by adjusting the underlying premium rate. The firm's objective is to minimize the total deviation of its cash-balance process to some pre-set target levels by selecting an appropriate premium policy. Our problem is totally new and has three distinguishable features: (1) both full and partial information cases are investigated here; (2) the state is subject to terminal constraint; (3) a forward–backward stochastic differential equation formulation is given which is more systematic and mathematically advanced. This formulation also enables us to continue further research in a generalized stochastic recursive control framework (see Duffie and Epstein (1992), El Karoui et al. (2001), etc.). The optimal premium policy with the associated optimal objective functional are completely and explicitly derived. In addition, a backward separation technique adaptive to forward–backward stochastic systems with the state constraint is presented as an efficient and convenient alternative to the traditional Wonham's (1968) separation principle in our partial information setup. Some concluding remarks are also given here.

KIESEL, S.; RÜSCHENDORF, L. *On optimal allocation of risk vectors*. 167-175. In this paper we extend results on optimal risk allocations for portfolios of real risks with relation to convex risk functionals to portfolios of risk vectors. In particular we characterize optimal allocations minimizing the total risk as well as Pareto optimal allocations. Optimal risk allocations are shown to exhibit a worst case dependence structure with relation to some specific max-correlation risk measure and they are comonotone with relation to a common worst case scenario measure. We also derive a new existence criterion for optimal risk allocations and discuss some examples.

KIM, J. H. T. *Bias correction for estimated distortion risk measure using the bootstrap*. 198-205.

The bias of the empirical estimate of a given risk measure has recently been of interest in the risk

management literature. In particular, Kim and Hardy (2007) showed that the bias can be corrected for the Conditional Tail Expectation (CTE, a.k.a. Tail-VaR or Expected Shortfall) using the bootstrap. This article extends their result to the distortion risk measure (DRM) class where the CTE is a special case. In particular, through the exact bootstrap, it is analytically proved that the bias of the empirical estimate of DRM with concave distortion function is negative and can be corrected on the bootstrap, using the fact that the bootstrapped loss is majorized by the original loss vector. Since the class of DRM is a subset of the L-estimator class, the result provides a sufficient condition for the bootstrap bias correction for L-estimators. Numerical examples are presented to show the effectiveness of the bootstrap bias correction. Later a practical guideline to choose the estimate with a lower mean squared error is also proposed based on the analytic form of the double bootstrapped estimate, which can be useful in estimating risk measures where the bias is non-cumulative across loss portfolio.

KO, B.; SHIU, E. S. W.; WEI, L. *Pricing maturity guarantee with dynamic withdrawal benefit*. 216-223. Motivated by the importance of withdrawal benefits for enhancing sales of variable annuities, we propose a new equity-linked product which provides a dynamic withdrawal benefit (DWB) during the contract period and a minimum guarantee at contract maturity. The term DWB is coined to reflect the duality between it and dynamic fund protection. Under the Black–Scholes framework and using results pertaining to reflected Brownian motion, we obtain explicit pricing formulas for the DWB payment stream and the maturity guarantee. These pricing formulas are also derived by means of Esscher transforms, which is another seminal contribution by Gerber to finance. In particular, we show that there are closed-form formulas for pricing European put and call options on a traded asset whose price can be modeled as the exponential of a reflected Brownian motion.

KOMELJ, J.; PERMAN, M. *Joint characteristic functions construction via copula*. 137-143. When modelling dependent risks it is important to be able to generate joint distributions with given marginals. One of the ways which may be useful in connection with using the Fast Fourier Transform is to construct joint characteristic functions from marginal characteristic functions. In this paper a class of n-dimensional continuous copulas is presented which in turn lead to a simple construction of joint characteristic functions with given marginal characteristic functions. Bounds on various measures of correlation are also given.

LI, J. S.-H. *Pricing longevity risk with the parametric bootstrap: A maximum entropy approach*. 176-186. In recent years, there has been significant development in the securitization of longevity risk. Various methods for pricing longevity risk have been proposed. In this paper we present an alternative pricing method, which is based on the maximization of the Shannon entropy in physics. Specifically, we propose implementing this pricing method with the parametric bootstrap (Brouhns et al., 2005), which is highly flexible and can be performed under different model assumptions. Through this pricing method we also quantify the impact of cohort effects and parameter uncertainty on prices of mortality-linked securities. Numerical illustrations based on longevity bonds with different maturities are provided.

NORBERG, R. *Forward mortality and other vital rates – are they the way forward?* 105-112. This paper presents a comparative study of stochastic interest and stochastic mortality showing that, despite a virtual similarity, the two concepts are fundamentally different. The notion of forward mortality rate, fetched from finance and now the latest thing in actuarial science, is predicted to soon go out of fashion. Trying it on, it does not fill the measurements of a well-made theoretical concept: there is an element of arbitrariness in its very definition, it disobeys certain self-evident

parity requirements, and it fails to generalize to more complex models. It is concluded that forward rate modelling, while passable in the context of interest, is not the way forward in the context of mortality and more general life history analysis.

QIAN, L.; WANG, R.; WANG, W.; TANG, Y. *Valuation of equity-indexed annuity under stochastic mortality and interest rate*. 123-129. An equity-indexed annuity (EIA) contract offers a proportional participation in the return on a specified equity index, in addition to a guaranteed return on the single premium. In this paper, we discuss the valuation of equity-indexed annuities under stochastic mortality and interest rate which are assumed to be dependent on each other. Employing the method of change of measure, we present the pricing formulas in closed form for the most common product designs: the point-to-point and the annual reset. Finally, we conduct several numerical experiments, in which we analyze the relationship between some parameters and the pricing of EIAs.

WU, Y.-C.; CHUNG, S.-L. *Catastrophe risk management with counterparty risk using alternative instruments*. 234-245. Since weather-related disasters have an upward trend-cycle movement and the global financial crisis has revealed the severity of counterparty risk, this study reinvestigates and incorporates the catastrophe characteristics and counterparty risk into the valuation of catastrophe products. First, the excess of loss reinsurance is traditionally used to reduce catastrophe risk. Its premium is estimated under these catastrophe characteristics. Second, this paper looks into the price of catastrophe futures and spread option contracts that are based on a catastrophe index. The (re)insurer can apply these exchange-traded derivatives to reduce catastrophe risk without counterparty risk. Third, this paper takes counterparty risk into account to value catastrophe bonds and catastrophe equity puts. Thus, the fair valuations of these two instruments are revealed to the buyer.

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CHEN, B.; ZHANG, L.; ZHAO, L. *On the robustness of longevity risk pricing*. 358-373. For longevity bond pricing, the most popular methods contain the risk-neutral method, the Wang transform and the Sharpe ratio rule. This paper studies robustness of these three methods and investigates connections and differences among them through theoretic analysis and numerical illustrations. We adopt the dynamic mortality models with jumps to capture the permanent effects caused by unexpected factors and allow the correlation between mortality and interest rate be nonzero. The analysis is based on four typical mortality models, including the mean-reverting models and the non mean-reverting ones. Our work may provide a guidance for participants on choice of pricing methods.

DEBÓN, A.; MARTÍNEZ-RUIZ, F.; MONTES, F. *A geostatistical approach for dynamic life tables: The effect of mortality on remaining lifetime and annuities*. 327-336. Dynamic life tables arise as an alternative to the standard (static) life table, with the aim of incorporating the evolution of

mortality over time. The parametric model introduced by Lee and Carter in 1992 for projected mortality rates in the US is one of the most outstanding and has been used a great deal since then. Different versions of the model have been developed but all of them, together with other parametric models, consider the observed mortality rates as independent observations. This is a difficult hypothesis to justify when looking at the graph of the residuals obtained with any of these methods. Methods of adjustment and prediction based on geostatistical techniques which exploit the dependence structure existing among the residuals are an alternative to classical methods. Dynamic life tables can be considered as two-way tables on a grid equally spaced in either the vertical (age) or horizontal (year) direction, and the data can be decomposed into a deterministic large-scale variation (trend) plus a stochastic small-scale variation (residuals). Our contribution consists of applying geostatistical techniques for estimating the dependence structure of the mortality data and for prediction purposes, also including the influence of the year of birth (cohort). We compare the performance of this new approach with different versions of the Lee–Carter model. Additionally, we obtain bootstrap confidence intervals for predicted  $q_{xt}$  resulting from applying both methodologies, and we study their influence on the predictions of  $e_{65t}$  and  $a_{65t}$ .

DELONG, L. *An optimal investment strategy for a stream of liabilities generated by a step process in a financial market driven by a Lévy process.* 278-293. In this paper we investigate an asset–liability management problem for a stream of liabilities written on liquid traded assets and non-traded sources of risk. We assume that the financial market consists of a risk-free asset and a risky asset which follows a geometric Lévy process. The non-tradeable factor (insurance risk or default risk) is driven by a step process with a stochastic intensity. Our framework allows us to consider financial risk, systematic and unsystematic insurance loss risk (including longevity risk), together with possible dependencies between them. An optimal investment strategy is derived by solving a quadratic optimization problem with a terminal objective and a running cost penalizing deviations of the insurer’s wealth from a specified profit-solvency target. Techniques of backward stochastic differential equations and the weak property of predictable representation are applied to obtain the optimal asset allocation.

DOWD, K.; CAIRNS, A. J. G.; BLAKE, D.; COUGHLAN, G. D.; EPSTEIN, D.; KHALAF-ALLAH, M. *Evaluating the goodness of fit of stochastic mortality models.* 255-265. This study sets out a framework to evaluate the goodness of fit of stochastic mortality models and applies it to six different models estimated using English & Welsh male mortality data over ages 64–89 and years 1961–2007. The methodology exploits the structure of each model to obtain various residual series that are predicted to be iid standard normal under the null hypothesis of model adequacy. Goodness of fit can then be assessed using conventional tests of the predictions of iid standard normality. The models considered are: Lee and Carter’s (1992) one-factor model, a version of Renshaw and Haberman’s (2006) extension of the Lee–Carter model to allow for a cohort-effect, the age-period-cohort model, which is a simplified version of the Renshaw–Haberman model, the 2006 Cairns–Blake–Dowd two-factor model and two generalized versions of the latter that allow for a cohort-effect. For the data set considered, there are some notable differences amongst the different models, but none of the models performs well in all tests and no model clearly dominates the others.

FREES, E. W.; SHI, P. *Long-tail longitudinal modeling of insurance company expenses.* 303-314. The insurance industry is known to have high operating expenses in the financial services sector. Insurers, investors and regulators are interested in models to understand the behavior of expenses. However, the current practice ignores skewness, occasional negative values as well as their

temporal dependence. Addressing these three features, this paper develops a longitudinal model of insurance company expenses that can be used for prediction, to identify unusual behavior, and to measure firm efficiency. Specifically, we use a three-parameter asymmetric Laplace density for the marginal distribution of insurers' expenses in each year. Copula functions are employed to accommodate their temporal dependence. As a function of explanatory variables, the location parameter allows us to analyze an insurer's expenses in light of the firm's characteristics. Our model can be interpreted as a longitudinal quantile regression. The analysis is performed using property-casualty insurance company data from the National Association of Insurance Commissioners of years 2001–2006. Due to the long-tailed nature of insurers' expenses, two alternative approaches are proposed to improve the performance of the longitudinal quantile regression model: rescaling and transformation. Predictive densities are derived that allow one to compare the predictions for individual insurers in a hold-out-sample. Both predictive models are shown to be reasonable with the rescaling method outperforming the transformation method. Compared with standard longitudinal models, our model is shown to be superior in identifying insurers' unusual behavior.

GOOVAERTS, M. J.; KAAS, R.; LAEVEN, R. J. A. *Decision principles derived from risk measures*. 294-302. In this paper, we argue that a distinction exists between risk measures and decision principles. Though both are functionals assigning a real number to a random variable, we think there is a hierarchy between the two concepts. Risk measures operate on the first "level", quantifying the risk in the situation under consideration, while decision principles operate on the second "level", often being derived from the risk measure. We illustrate this distinction with several canonical examples of economic situations encountered in insurance and finance. Special attention is paid to the role of axiomatic characterizations in determining risk measures and decision principles. Some new axiomatic characterizations of families of risk measures and decision principles are also presented.

HASHORVA, E.; PAKES, A. G.; TANG, Q. *Asymptotics of random contractions*. 405-414. In this paper we discuss the asymptotic behaviour of random contractions  $X=RS$ , where  $R$ , with distribution function  $F$ , is a positive random variable independent of  $S(0,1)$ . Random contractions appear naturally in insurance and finance. Our principal contribution is the derivation of the tail asymptotics of  $X$  assuming that  $F$  is in the max-domain of attraction of an extreme value distribution and the distribution function of  $S$  satisfies a regular variation property. We apply our result to derive the asymptotics of the probability of ruin for a particular discrete-time risk model. Further we quantify in our asymptotic setting the effect of the random scaling on the Conditional Tail Expectations, risk aggregation, and derive the joint asymptotic distribution of linear combinations of random contractions.

LABUSCHAGNE, C. C. A.; OFFWOOD, T. M. *A note on the connection between the Esscher–Girsanov transform and the Wang transform*. 385-390. An elementary proof is presented to show that a connection exists between the Esscher–Girsanov transform and the Wang transform.

LIEW, C. C.; SIU, T. K. *A hidden Markov regime-switching model for option valuation*. 374-384. We investigate two approaches, namely, the Esscher transform and the extended Girsanov's principle, for option valuation in a discrete-time hidden Markov regime-switching Gaussian model. The model's parameters including the interest rate, the appreciation rate and the volatility of a risky asset are governed by a discrete-time, finite-state, hidden Markov chain whose states represent the hidden states of an economy. We give a recursive filter for the hidden Markov chain

and estimates of model parameters using a filter-based EM algorithm. We also derive predictors for the hidden Markov chain and some related quantities. These quantities are used to estimate the price of a standard European call option. Numerical examples based on real financial data are provided to illustrate the implementation of the proposed method.

MA, J.; YUN, Y. *Correlated intensity, counter party risks, and dependent mortalities*. 337-351. In this paper we use an intensity-based framework to analyze and compute the correlated default probabilities, both in finance and actuarial sciences, following the idea of “change of measure” initiated by Collin-Dufresne et al. (2004). Our method is based on a representation theorem for joint survival probability among an arbitrary number of defaults, which works particularly effectively for certain types of correlated default models, including the counter-party risk models of Jarrow and Yu (2001) and related problems such as the phenomenon of “flight to quality”. The results are also useful in studying the recently observed dependent mortality for married couples involving spousal bereavement. In particular we study in details a problem of pricing Universal Variable Life (UVL) insurance products. The explicit formulae for the joint-life status and last-survivor status (or equivalently, the probability distribution of first-to-default and last-to-default in a multi-firm setting) enable us to derive the explicit solution to the indifference pricing formula without using any advanced results in partial differential equations.

PSARRAKOS, G. *On the DFR property of the compound geometric distribution with applications in risk theory*. 428-433. In 1988, Shanthikumar proved that the sum of a geometrically distributed number of i.i.d. DFR random variables is also DFR. In this paper, motivated by the inverse problem, we study monotonicity properties related to defective renewal equations, and obtain that if a compound geometric distribution is DFR, then the random variables of the sums are NWU (a class that contains DFR). Furthermore, we investigate some applications of risk theory and give a characterization of the exponential distribution.

RUNGGALDIER, W. J.; EDOLI, E. *On optimal investment in a reinsurance context with a point process market model*. 315-326. We study an insurance model where the risk can be controlled by reinsurance and investment in the financial market. We consider a finite planning horizon where the timing of the events, namely the arrivals of a claim and the change of the price of the underlying asset(s), corresponds to a Poisson point process. The objective is the maximization of the expected total utility and this leads to a nonstandard stochastic control problem with a possibly unbounded number of discrete random time points over the given finite planning horizon. Exploiting the contraction property of an appropriate dynamic programming operator, we obtain a value-iteration type algorithm to compute the optimal value and strategy and derive its speed of convergence. Following Schäl (2004) we consider also the specific case of exponential utility functions whereby negative values of the risk process are penalized, thus combining features of ruin minimization and utility maximization. For this case we are able to derive an explicit solution. Results of numerical computations are also reported.

RUSSO, R. P.; SHYAMALKUMAR, N. D. *Bounds for the bias of the empirical CTE*. 352-357. The Conditional Tail Expectation (CTE) is gaining an increasing level of attention as a measure of risk. It is known that nonparametric unbiased estimators of the CTE do not exist, and that, the empirical  $\alpha$ -level CTE (the average of the  $n(1-\alpha)$  largest order statistics in a random sample of size  $n$ ), is negatively biased. In this article, we show that increasing convex order among distributions is preserved by. From this result it is possible to identify the specific distributions, within some large classes of distributions, that maximize the bias of. This in turn leads to best

possible bounds on the bias under various sets of conditions on the sampling distribution  $F$ . In particular, we show that when the  $\alpha$ -level quantile is an isolated point in the support of a non-degenerate distribution (for example, a lattice distribution) then the bias is either of the order or vanishes exponentially fast. This is intriguing as the bias vanishes at the in-between rate of  $1/n$  when  $F$  possesses a positive derivative at the  $\alpha^{\text{th}}$  quantile.

STADJE, M. *Extending dynamic convex risk measures from discrete time to continuous time: A convergence approach*. 391-404. We present an approach for the transition from convex risk measures in a certain discrete time setting to their counterparts in continuous time. The aim of this paper is to show that a large class of convex risk measures in continuous time can be obtained as limits of discrete time-consistent convex risk measures. The discrete time risk measures are constructed from properly rescaled ('tilted') one-period convex risk measures, using a  $d$ -dimensional random walk converging to a Brownian motion. Under suitable conditions (covering many standard one-period risk measures) we obtain convergence of the discrete risk measures to the solution of a BSDE, defining a convex risk measure in continuous time, whose driver can then be viewed as the continuous time analogue of the discrete 'driver' characterizing the one-period risk. We derive the limiting drivers for the semi-deviation risk measure, Value at Risk, Average Value at Risk, and the Gini risk measure in closed form.

VAN HAASTRECHT, A.; PLAT, R.; PELSSER, A. *Valuation of guaranteed annuity options using a stochastic volatility model for equity prices*. 266-277. Guaranteed annuity options are options providing the right to convert a policyholder's accumulated funds to a life annuity at a fixed rate when the policy matures. These options were a common feature in UK retirement savings contracts issued in the 1970's and 1980's when interest rates were high, but caused problems for insurers as the interest rates began to fall in the 1990's. Currently, these options are frequently sold in the US and Japan as part of variable annuity products. The last decade the literature on pricing and risk management of these options evolved. Until now, for pricing these options generally a geometric Brownian motion for equity prices is assumed. However, given the long maturities of the insurance contracts a stochastic volatility model for equity prices would be more suitable. In this paper explicit expressions are derived for prices of guaranteed annuity options assuming stochastic volatility for equity prices and either a 1-factor or 2-factor Gaussian interest rate model. The results indicate that the impact of ignoring stochastic volatility can be significant.

WILLMOT, G. E. *Distributional analysis of a generalization of the Polya process*. 423-427. A nonhomogeneous birth process generalizing the Polya process is analyzed, and the distribution of the transition probabilities is shown to be the convolution of a negative binomial distribution and a compound Poisson distribution, whose secondary distribution is a mixture of zero-truncated geometric distributions. A simplified form of the secondary distribution is obtained when the transition intensities have a particular structure, and may sometimes be expressed in terms of Stirling numbers and special functions such as the incomplete gamma function, the incomplete beta function, and the exponential integral. Conditions under which the compound Poisson form of the marginal distributions may be improved to a geometric mixture are also given.

XU, G.; ZHENG, H. *Basket options valuation for a local volatility jump-diffusion model with the asymptotic expansion method*. 415-422. In this paper we discuss the basket options valuation for a jump-diffusion model. The underlying asset prices follow some correlated local volatility diffusion processes with systematic jumps. We derive a forward partial integral differential equation (PIDE) for general stochastic processes and use the asymptotic expansion method to

approximate the conditional expectation of the stochastic variance associated with the basket value process. The numerical tests show that the suggested method is fast and accurate in comparison with the Monte Carlo and other methods in most cases.

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Journal of Risk and Insurance

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BATES, L. J.; MUKHERJEE, K.; SANTERRE, R. E. *Medical insurance coverage and health production efficiency*. 211-229. Conventional economic theory predicts that medical insurance coverage causes an inefficient production of health because of ex ante and ex post moral hazard effects. However, no research has empirically examined the magnitude of the inefficiency. This study empirically examines the impact of medical insurance on the technical efficiency of health production at the metropolitan level. The underlying health production function allows for preventive care, curative care, and behavioural factors. Data envelopment analysis determines relative technical efficiency. The multiple regression results indicate that insurance coverage generates inefficiency but the efficiency loss appears to be relatively small on the extensive margin.

BHATTACHARYA, J.; NEUHAUSER, F.; REVILLE, R. T.; SEABURY, S. A. *Evaluating permanent disability ratings using empirical data on earnings losses*. 231-260. Workers' compensation systems are typically designed to assign higher permanent disability benefits to workers with more severe disabilities. However, little or no scientific work exists to guide the design of ratings systems to properly account for the amount of earnings power lost due to disability. In this article, we examine the effectiveness of disability ratings using matched administrative data on ratings and earnings for a large, representative sample of permanent disability claimants in California. We find that while workers with higher ratings do experience larger earnings losses on average, there are large and persistent differences in average earnings losses for similarly rated impairments in different parts of the body. We then explore how adjusting permanent disability ratings to reflect cross-impairment differences in earnings losses can affect the equity of permanent disability benefits. Adjusting disability ratings to account for typical earnings losses reduces cross-impairment differences substantially. The adjusted ratings result in a more equitable distribution of disability benefits across workers with different impairments.

BUNDORE, M. K. *The effects of offering health plan choice within employment-based purchasing groups*. 105-127. Employers may offer employees a choice of health plans either to promote competition among plans or to better cater to employee preferences for different types of products. This article examines whether the relationship between the availability of choice and insurance costs and coverage are consistent with these models of employer behaviour. The results indicate that employers who offer choice have lower average premiums, primarily because employees are enrolled in less generous plans, and cover a greater proportion of workers than those who do not. The results are consistent with employers offering choice to accommodate diverse worker preferences.

CARDON, J. H. *Flexible spending accounts and adverse selection*. 145-153. Article that models the interaction of flexible spending accounts (FSAs) and conventional insurance in a simple discrete loss setting with asymmetric information. It shows that FSA availability can break a separating equilibrium, even when one would otherwise exist, because high-risk types might prefer the lower-coverage contract supplemented with FSA funds. In this case there may exist a Pareto-inferior separating equilibrium. It is also shown that FSA availability alters the optimal pooling contract. Employers can reduce coverage levels, raising expected utility for low-risk types, and can compensate high-risk types by offering supplemental FSA coverage. Thus, it is possible that FSAs strengthen pooling contracts.

COHEN, A.; SIEGELMAN, P. *Testing for adverse selection in insurance markets*. 39-84. This article reviews and evaluates the empirical literature on adverse selection in insurance markets. We focus on empirical work that seeks to test the basic coverage–risk prediction of adverse selection theory—that is, that policyholders who purchase more insurance coverage tend to be riskier. The analysis of this body of work, we argue, indicates that whether such a correlation exists varies across insurance markets and pools of insurance policies. We discuss various reasons why a coverage–risk correlation may not be found in some pools of insurance policies. The presence of a coverage–risk correlation can be explained either by moral hazard or adverse selection, and we discuss methods for distinguishing between them. Finally, we review the evidence on learning by policyholders and insurers.

DUSANSKY, R.; KOC, C. *Implications of the interaction between insurance choice and medical care demand*. 129-144. The gross price elasticity of demand for medical care is decomposed into two separate observable components: the medical care gross price elasticity of insurance choice and the cost-sharing elasticity of medical care. When consumers alter their choice of health-care plans, the price elasticity of medical care is no longer equivalent to the cost-sharing elasticity; using the latter as a proxy for the former may produce misleading results. We present conditions under which the medical care price elasticity is positive, the case of a quasi-Giffen good, and provide a theoretical foundation for extant empirical findings of a positive medical care price elasticity of insurance demand.

HARRINGTON, S. E. *The health insurance reform debate*. 5-38. This article provides an overview of the U.S. health care reform debate and legislation, with a focus on health insurance. Following a synopsis of the main problems that confront U.S. health care and insurance, it outlines the health care reform bills in the U.S. House and Senate as of early December 2009, including the key provisions for expanding and regulating health insurance, and projections of the proposals' costs, funding, and impact on the number of people with insurance. The article then discusses (1) the potential effects of the mandate that individuals have health insurance in conjunction with proposed premium subsidies and health insurance underwriting and rating restrictions, (2) the proposed creation of a public health insurance plan and/or nonprofit cooperatives, and (3) provisions that would modify permissible grounds for health policy rescission and repeal the limited antitrust exemption for health and medical liability insurance. It concludes by contrasting the reform bills with market-oriented proposals and with brief perspective on future developments.

JUNG, K. *Incentives for voluntary disclosure of quality information in HMO markets*. 183-210. This study examines incentives for voluntary disclosure of quality information by health maintenance organizations (HMOs). Economic theory predicts complete voluntary disclosure

without mandatory rules. This article introduces plans' selection motives to avoid high-risk consumers as a deterrent of full unravelling; if disclosure is expected to attract high-risk members, plans have incentives to withhold information. The empirical analysis shows that while market unravelling was an important mechanism to bring disclosure, it was not complete, and plans in markets with high-risk consumers were less likely to disclose. This study suggests that market unravelling may not arise if risk selection incentives are prevalent.

LO SASSO, A. T.; HELMCHEN, L. A.; KAESTNER, R. *The effect of consumer-directed health plans on health care spending*. 85-103. We use unique data from an insurer that exclusively offers high-deductible, "consumer-directed" health plans to identify the effect of plan features, notably employer contributions to the spending account, on health care spending. Our results show that the marginal dollar contributed by the employer to the spending account is entirely spent on outpatient and pharmacy services. In contrast, out-of-pocket spending was not responsive to the amount the employer contributes to the spending account. Our results represent the first plausibly causal estimates of the components of consumer-driven health plans on health spending. The magnitudes of the effects suggest important health care spending consequences to higher employer contributions to spending accounts. Our findings are most directly relevant to health reimbursement arrangement plan designs, though our results are still of value to health savings account plan designs.

MACDONALD, A.; TAPADAR, P. *Multifactorial genetic disorders and adverse selection: Epidemiology meets economics*. 155-182. The focus of genetics is shifting its contribution to common, complex disorders. New genetic risk factors will be discovered, which if undisclosed may allow adverse selection. However, this should happen only if low-risk individuals would reduce their expected utility by insuring at the average price. We explore this boundary, focusing on critical illness insurance and heart attack risk. Adverse selection is, in many cases, impossible. Otherwise, it appears only for lower risk aversion and smaller insured losses, or if the genetic risk is implausibly high. We find no strong evidence that adverse selection from this source is a threat.

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## Journal of Risk and Insurance

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CHEN, M.-C.; CHANG, C.-C.; LIN, S.-K.; SHYU, S.-D. *Estimation of housing price jump risks and their impact on the valuation of mortgage insurance contracts*. 399-422. Housing price jump risk and the subprime crisis have drawn more attention to the precise estimation of mortgage insurance premiums. This study derives the pricing formula for mortgage insurance premiums by assuming that the housing price process follows the jump diffusion process, capturing important characteristics of abnormal shock events. This assumption is consistent with the empirical observation of the U.S. monthly national average new home returns from 1986 to 2008. Furthermore, we investigate the impact of price jump risk on mortgage insurance premiums from shock frequency of the abnormal events, abnormal mean and volatility of jump size, and normal volatility. Empirical results indicate that the abnormal volatility of jump size has the most significant impact on mortgage insurance premiums.

CHENG, J.; ELYASIANI, E.; LIN, T.-T. *Market reaction to regulatory action in the insurance industry: The case of contingent commission*. 347-368. We examine the market's reaction to New York Attorney General Eliot Spitzer's civil suit against mega-broker Marsh for bid rigging and inappropriate use of contingent commissions within a generalized autoregressive conditionally heteroskedastic (GARCH) framework. Effects on the stock returns of insurance brokers and insurers are tested. The findings are: (1) GARCH effects are significant in modelling broker/insurer returns; (2) the suit generated negative effects on the brokerage industry and individual brokers, suggesting that contagion dominates competitive effects; (3) spillover effects from the brokerage sector to insurance business are significant and mostly negative, demonstrating industry integration; and (4) information-based contagion is supported, as opposed to the pure-panic contagion.

ECKLES, D. L.; HALEK, M. *Insurer reserve error and executive compensation*. 329-346.

This article investigates incentives of insurance firm managers to manipulate loss reserves in order to maximize their compensation. We find that managers who receive bonuses that are likely capped or no bonuses tend to over-reserve for current-year incurred losses. However, managers who receive bonuses that are likely not capped tend to under-reserve for current-year incurred losses. We also find that managers who exercise stock options tend to under-reserve in the current period.

HE, A.; SOMMER, D. W. *Separation of ownership and control: implications for board composition*. 265-295. This article investigates the implications of separation of ownership and control for board composition over a spectrum of ownership structures present in the U.S. property-liability insurance industry. We hypothesize that agency costs associated with manager-owner conflicts increase with the degree of separation of ownership and control. Greater agency costs imply a greater need for monitoring by outside directors on the board. Therefore, use of outside directors is expected to increase as the separation of ownership and control gets larger. Employing a sample of property-liability insurers exhibiting different degrees of separation of ownership and control, we find support for our hypothesis.

HUANG, H.-C. *Optimal multiperiod asset allocation: Matching assets to liabilities in a discrete model*. 451-472. Investment and risk control are becoming increasingly important for financial institutions. Asset allocation provides a fundamental investing principle to manage the risk and return trade-off in financial markets. This article proposes a general formulation of a first approximation of multiperiod asset allocation modeling for institutions that invest to meet the target payment structures of a long-term liability. By addressing the shortcomings of both single-period models and the single-point forecast of the mean variance approach, this article derives explicit formulae for optimal asset allocations, taking into account possible future realizations in a multiperiod discrete time model.

LI, J. S.-H.; HARDY, M. R.; TAN, K. S. *On pricing and hedging the no-negative-equity guarantee in equity release mechanisms*. 499-522. In a roll-up mortgage, the borrower receives a loan in the form of a lump sum. The loan is rolled up with interest until the borrower dies, sells the house, or moves into long-term care permanently. The house is sold at that time, and the proceeds are used to repay the loan and interest. Most roll-up mortgages are sold with a no-negative-equity guarantee (NNEG), which caps the redemption amount at the lesser of the face amount of the loan and the sale proceeds. The core of this study is to develop a framework for pricing and managing the risks of the NNEG.

MAYERS, D.; SMITH, C. W. *Compensation and board structure: evidence from the insurance industry*. 297-327. Monitoring by outside board members and incentive compensation provisions in executive pay packages are alternative mechanisms for controlling incentive problems between owners and managers. The control hypothesis suggests that if incentive conflicts vary materially, those firms with more outside directors also should implement a higher degree of pay-for-performance sensitivity. Our evidence is consistent with this control hypothesis. We document a relation between board structure and the extent to which executive compensation is tied to performance in mutuals: compensation changes are significantly more sensitive to changes in return on assets when the fraction of outsiders on the board is high.

MICHEL-KERJAN, E.; KOUSKY, C. *Come rain or shine: Evidence on flood insurance purchases in Florida*. 369-397. This article provides a detailed analysis of the operation of the National Flood Insurance Program (NFIP) in Florida, which accounts for 40 percent of the NFIP portfolio. We study the demand for flood insurance with a data set of more than 7.5 million NFIP policies-in-force (the largest ever studied) for the years 2000–2005, as well as all NFIP claims filed in Florida. We answer four questions: What are the characteristics of the buyers of flood insurance? What types of contracts (deductibles and coverage levels) are purchased? What are the determinants of claims payments? How are prices determined and how much does NFIP insurance cost?

POST, T.; SCHULZE, R. N. *Individual annuity demand under aggregate mortality risk*. 423-449. Aggregate mortality risk—the risk that the mortality trend in a population changes in a nondeterministic way—and its implications for corporate decisions has recently been the subject of lively scientific discussion. We show that aggregate mortality risk is also a key determinant for individual annuitization decisions. Aggregate mortality risk appears to be a risk very difficult to transfer for individuals. Whether its existence leads to a higher or lower annuity demand depends on objective factors (e.g., insurers' vulnerability to aggregate mortality changes). Subjective factors (i.e., individuals' preferences) determine only the intensity of the annuity demand reaction to aggregate mortality risk. Our results are of significant importance not only for financial planning approaches of individual annuity buyers but also for strategic decisions in insurance companies and for solvency regulators. Furthermore, consideration of aggregate mortality risk may alleviate, but also intensify, the annuity puzzle.

WANG, J. L.; HUANG, H. C.; YANG, S. S.; TSAI, J. T. *An optimal product mix for hedging longevity risk in life insurance companies: The immunization theory approach*. 473-497. This article investigates the natural hedging strategy to deal with longevity risks for life insurance companies. We propose an immunization model that incorporates a stochastic mortality dynamic to calculate the optimal life insurance–annuity product mix ratio to hedge against longevity risks. We model the dynamic of the changes in future mortality using the well-known Lee–Carter model and discuss the model risk issue by comparing the results between the Lee–Carter and Cairns–Blake–Dowd models. On the basis of the mortality experience and insurance products in the United States, we demonstrate that the proposed model can lead to an optimal product mix and effectively reduce longevity risks for life insurance companies.

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BERNARD, C.; LE COURTOIS, O.; QUITTARD-PINON, F. *Protection of a Company Issuing a Certain Class of Participating Policies in a Complete Market Framework*. 131-149. In this article we examine to what extent policyholders buying a certain class of participating contracts (in which they are entitled to receive dividends from the insurer) can be described as standard bondholders. Our analysis extends the ideas of Buhlmann and sequences the fundamental advances of Merton, Longstaff and Schwartz, and Briys and de Varenne. In particular, we develop a setup where these participating policies are comparable to hybrid bonds but not to standard risky bonds (as done in most papers dealing with the pricing of participating contracts). In this mixed framework, policyholders are only partly protected against default consequences. Continuous and discrete protections are also studied in an early default Black and Cox-type setting. A comparative analysis of the impact of various protection schemes on ruin probabilities and severities of a life insurance company that sells only this class of contracts concludes this work.

LEE, S. S. K.; LIN, X. S. *Modeling and Evaluating Insurance Losses via Mixtures of Erlang Distributions*. 107-130. In this paper we suggest the use of mixtures of Erlang distributions with common scale parameter to model insurance losses. A modified expectation-maximization (EM) algorithm for parameter estimation tailored to this class of distributions is presented, and its computation efficiency is discussed. Goodness-of-fit tests are performed for data generated from some common parametric distributions and for catastrophic loss data in the United States. Formulas for value-at-risk and conditional tail expectation are provided for individual and aggregate losses.

LOMBARDI, L. J. *Monitoring Changes in Capital and Hedge Effectiveness Under Fair Value Accounting Principles*. 1-15. In the early 1970s Richard G. Horn established a methodology for analysing the earnings of a life insurance company that reflected, at that time, the types of products underwritten and the accounting principles that were in effect. This methodology became to be known as a “sources of earnings analysis.” With the exception of term life insurance, most life insurance and annuity products underwritten today have significant equity risk. Furthermore, fair value accounting principles are replacing historical-based accounting principles. Finally, life insurance companies have sophisticated risk management policies and procedures to manage risk. The purpose of this paper is to extend Horn’s “sources of earnings analysis” to reflect the evolution in product design, accounting standards, and risk management practices. In particular, under fair value accounting principles, the capital account becomes the primary focus of attention. Accordingly, this paper develops a methodology to perform an “analysis of the change in capital” that would replace a traditional “sources of earnings analysis.” In addition, most life insurance companies have hedging programmes to manage the embedded equity risks in the types of products they have underwritten. Thus, an important focus of this analysis is to monitor the effectiveness of these hedging programmes.

MARSHALL, C.; HARDY, M.; SAUNDERS, D. *Valuation of a Guaranteed Minimum Income Benefit*. 38-58. With a deferred variable annuity the policyholder pays an upfront premium to the insurance company, which is then invested in the financial markets for many years (the accumulation phase) until the policyholder decides to convert their investment (often at retirement age) into a stream of variable annuity payments. A Guaranteed Minimum Income

Benefit (GMIB) is an option that may be included at inception of a variable annuity contract that, in exchange for small fees charged by the insurer, gives the policyholder a right to receive a guaranteed minimum level of annuity payments upon annuitization. A GMIB is an attractive option because it protects the policyholder's investment against poor market performance during the accumulation phase. The value of a GMIB is affected by investment account returns, interest rates, and mortality. The intention of this paper is to value a GMIB in a complete market, focusing on the sensitivity of the GMIB value to the financial variables. Mortality is not incorporated into the valuation. We present a comprehensive sensitivity analysis of the model employed. We decompose a GMIB payoff, which is rather complicated, to analyze what drives the value of a GMIB. Our approach offers a simple but effective way for insurers to measure the value of the GMIBs they offer, and it provides insights into the risk management of GMIBs and other guarantees that provide similar payoffs. Our model suggests that the fee rates charged by insurance companies for the GMIB option may be too low.

MODISETT, M. C.; MABOUDOU-TCHAO, E. M. *Significantly Lower Estimates of Volatility Arise from the Use of Open-High-Low-Close Price Data*. 68-85. This research provides an indication of the possible reduction in insurance liability valuations arising from the reduced volatility estimate of the Yang-Zhang refinement of volatility, when the liabilities are based on historic prices estimates arising from end-of-day prices in a jump-diffusion model. The paper also demonstrates the usefulness of change points. This research compares the standard measure of volatility (standard deviation of the log of close prices) for the total return of the S&P 500 to a recently developed volatility measure by Yang and Zhang that capitalizes on open-high-low-close prices. The latter volatility was developed to be the measure providing the narrowest confidence interval of all estimates satisfying certain desirable features and as such is the most desirable measure from a decision theory standpoint. This research shows that the Yang-Zhang volatility generally provides significantly lower estimates of volatility. This lower volatility estimate should lead to lower valuation levels for insurance products with guarantees, and this paper provides indicative reductions in liability valuations. Both volatility measures assume constant volatility and drift over a period. To accommodate this assumption, change points are employed to divide historical data into regimes of constant drift and volatility. To this end, the theory of change points is briefly introduced. The research shows that standard measure of volatility generally overestimates volatility, and the error increases with the absolute value of the underlying drift. There are several potential technical reasons why the lower volatility could be invalid, but this paper considers and rejects each, to conclude that the lower volatility estimate of Yang-Zhang is in fact the better estimate, not a result of a technical degeneracy. One conclusion is that valuations employing regime-switching generators, especially insurance liability valuations, should use the Yang-Zhang measure of volatility, otherwise any analysis embedded (or free-standing) options could overvalue prices or volatility. The simplicity of the Yang-Zhang calculation and its potentially large impact on valuations should justify its adoption for most companies.

TIAN, R.; COX, S. H.; LIN, Y.; ZULUAGA, L. F. *Portfolio Risk Management with CVaR-like Constraints*. 86-106. A current research stream in the portfolio allocation literature develops models that take into account the asymmetric nature of asset return distributions. Our paper contributes to this research stream by extending the Krokmal, Palmquist, and Uryasev approach. We add CVaR-like constraints in the traditional portfolio optimization problem to reshape the tails of the portfolio return distribution while not significantly affecting its mean and variance. We illustrate how to apply this approach, called the "MV + CVaR approach," to manage tail risk of an insurer's asset-liability portfolio. Finally, we compare the MV+CVaR

approach with the traditional Markowitz method and a method recently introduced by Boyle and Ding. Our numerical analysis provides empirical support for the effectiveness of the MV + CVaR approach in controlling downside risk. Moreover, we find that the MV + CVaR approach may improve skewness of mean-variance portfolios, especially for high-variance portfolios.

ULM, E. R. *The Effect of Policyholder Transfer Behavior on the Value of Guaranteed Minimum Death Benefits*. 16-37. Variable annuity contracts frequently include both guaranteed minimum death benefit (GMDB) options and options to transfer funds between fixed and variable accounts. We model the difference between fixed and variable rates as the primary determinant of policyholder transfer behaviour. We find that people tend to transfer their money into variable accounts at about 39% of the rate that would be required to maintain constant percentage rebalancing, but with the opposite sign. If these transfers are not taken into account, the GMDB options on the variable accounts will be overvalued and overhedged. Ignoring this effect can have a substantial impact on the size of the futures portfolio needed to hedge this risk and a nonnegligible impact on the earnings of the variable annuity portfolio.

ZULUAGA, L. F.; COX, S. H. *Improving Skewness of Mean-Variance Portfolios*. 59-85. The widely accepted belief that asset returns and insurance product line margins are not normally distributed has motivated the use of skewness (or higher than second-order moments) in the context of optimal risk-reward portfolio allocation. Here we propose an optimization-based methodology to substantially improve the skewness of portfolios in the mean-variance efficient frontier. Unlike other related methods, the proposed methodology is very intuitive, noniterative, and simple to implement, and it can be readily and efficiently carried out using state-of-the-art optimization solvers. These characteristics should be very appealing to risk managers.

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## North American Actuarial Journal

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AHN, J. Y.; SHYAMALKUMAR, N. D. *An Asymptotic Analysis of the Bootstrap Bias Correction for the Empirical CTE*. 217-234. The  $\alpha$ -level Conditional Tail Expectation (CTE) of a continuous random variable  $X$  is defined as its conditional expectation given the event  $\{X > q_\alpha\}$ , where  $q_\alpha$  represents its  $\alpha$ -level quantile. It is well known that the empirical CTE (the average of the  $n(1-\alpha)$  largest order statistics in a sample of size  $n$ ) is a negatively biased estimator of the CTE. This bias vanishes as the sample size increases but in small samples can be significant. Hence the need for bias correction. Although the bootstrap method has been suggested for correcting the bias of the empirical CTE, recent research shows that alternate kernel-based methods of bias correction perform better in some practical examples. To further understand this phenomenon, we conduct an asymptotic analysis of the exact bootstrap bias correction for the empirical CTE, focusing on its performance as a point estimator of the bias of the empirical CTE. We provide heuristics

suggesting that the exact bootstrap bias correction is approximately a kernel-based estimator, albeit using a bandwidth that converges to zero faster than mean square optimal bandwidths. This approximation provides some insight into why the bootstrap method has markedly less residual bias, but at the cost of having higher variance. We prove a central limit theorem (CLT) for the exact bootstrap bias correction using an alternate representation as an  $I^1$  distance of the sample observations from the  $\alpha$ -level empirical quantile. The CLT, in particular, shows that the bootstrap bias correction has a relative error of  $n^{-1/4}$ . In contrast, for any given  $\varepsilon > 0$ , and under the assumption that the sampling density is sufficiently smooth, relative error of order  $O(n^{-1/2+\varepsilon})$  is attainable using kernel-based estimators. Thus, in an asymptotic sense, the bootstrap bias correction as a point estimator of the bias is not optimal in the case of smooth sampling densities. Bootstrapped risk measures have recently found interest as estimators in their own right; as an application we derive the CLT for the bootstrap expectation of the empirical CTE. We also report on a simulation study of the effect of small sample sizes on the quality of the approximation provided by the CLT. In support of the bootstrap method we show that the bootstrap bias correction is optimal if the sampling density is constrained only to be Lipschitz of order  $\frac{1}{2}$  (or, loosely speaking, to have only *half a derivative*). Because in practice densities are at least twice differentiable, this optimality result largely fails to make the bootstrap method attractive to practitioners.

EMMS, P. *Relative Choice Models for Income Drawdown in a Defined Contribution Pension Scheme*. 176-197. This paper extends a target-based model of income drawdown developed in Gerrard et al. (*Insurance: Mathematics and Economics* 35: 321–342 [2006]) (GHV) for the distribution phase of a defined contribution pension scheme. The optimal investment strategy of the pension fund and the optimal drawdown are found using linear-quadratic optimization, which minimizes the deviation of the fund and the drawdown from prescribed targets. The GHV model is modified by nondimensionalizing the loss function, so that there is a relative choice between outcomes. Using this model, three classes of target are studied. Endogenous deterministic targets are suggested from the form of the optimal controls, while exogenous deterministic targets can be stated without knowledge of the optimization problem. The third class of stochastic targets is similar to recent annuity products, which incorporate investment risk. Each scheme represents a trade-off between investment risk and return, and this is illustrated by numerical simulation with reference to a canonical example. A particularly attractive form of income drawdown is given by an implied rate of return target. This yields a reasonable investment strategy and a robust consumption profile with age. In addition, it can be easily explained to pension scheme members.

GERBER, H. U.; SHIU, E. S. W. *Discussion of "Weighted Pricing Functionals with Applications to Insurance: An Overview"*. A discussion of "Weighted Pricing Functionals with Applications to Insurance: An Overview," Edward Furman and Ricardas Zitikis, *North American Actuarial Journal*, Vol. 13, No. 4, 2009. The authors are to be thanked for their survey paper. We shall present two comments, one on Section 2 and the other on Section 3. A preliminary comment is that the "actuarial weighted pricing functionals" in Section 2 differ substantially from the "economic weighted pricing functionals" in Section 3.

GOLDEN, L. L.; YANG, C. C.; ZOU, H. *The Effectiveness of Using a Basis Hedging Strategy to Mitigate the Financial Consequences of Weather-Related Risks*. 157-175. This paper examines the effectiveness of using a hedging strategy involving a basis derivative instrument to reduce the negative financial consequences of weather-related risks. We examine the effectiveness of using

this basis derivative strategy for both summer and winter seasons, using both linear and nonlinear hedging instruments and the impacts of default risk and perception errors on weather hedging efficiency. We also compare the hedging effectiveness obtained using weather indices produced by both the Chicago Mercantile Exchange (CME) and Risk Management Solutions, Inc. (RMS). The results indicate that basis hedging is significantly more effective for the winter season than for the summer season, whether using the CME or RMS weather indices, and whether using linear or nonlinear derivative instruments. It is also found that the RMS regional weather indices are more effective than the CME weather indices, and the effectiveness of using either linear or nonlinear hedging instruments for weather risk management can vary significantly depending on the region of the country. In addition, the results indicate that default risk has some impact on nonlinear basis hedging efficiency but no impact on linear basis hedging efficiency, and reasonable perception errors on default risk have no impact on either linear or nonlinear basis hedging efficiency.

KIM, J.H. T. *Conditional Tail Moments of the Exponential Family and its Related Distributions*. 198-216. The risk measure is a central theme in the risk management literature. For good reasons, the conditional tail expectation (CTE) has received much interest in both insurance and finance applications. It provides for a measure of the expected riskiness in the tail of the loss distribution. In this article we derive explicit formulas of the CTE and higher moments for the univariate exponential family class, which extends the natural exponential family, using the canonical representation. In addition we show how to compute the conditional tail expectations of other related distributions using transformation and conditioning. Selected examples are presented for illustration, including the generalized Pareto and generalized hyperbolic distributions. We conclude that the conditional tail expectations of a wide range of loss distributions can be analytically obtained using the methods shown in this article.

VANDUFFEL, S. *Discussion of "Weighted Pricing Functionals with Applications to Insurance: An Overview"*. 278-279. A discussion of "Weighted Pricing Functionals with Applications to Insurance: An Overview," Edward Furman and Ricardas Zitikis, North American Actuarial Journal, Vol. 13, No. 4, 2009. The authors are to be congratulated with this timely and well-written overview paper on weighted pricing functionals. In Section 5 the authors analyze Stein-type arguments for assessing pricing functionals. In this discussion we provide an extension for these results, and we briefly discuss a further property of these pricing functionals.

WÜTHRICH, M. V. *Accounting Year Effects Modeling in the Stochastic Chain Ladder Reserving Method*. 235-255. In almost all stochastic claims reserving models one assumes that accident years are independent. In practice this assumption is violated most of the time. Typical examples are claims inflation and accounting year effects that influence all accident years simultaneously. We study a Bayesian chain ladder model that allows for accounting (calendar) year effects modeling. A case study of a general liability dataset shows that such accounting year effects contribute substantially to the prediction uncertainty and therefore need a careful treatment within a risk management and solvency framework.

YUEN, F. L.; YANG, H. *Pricing Asian Options and Equity-Indexed Annuities with Regime Switching by the Trinomial Tree Method*. 256-277. Equity-indexed annuities (EIAs) provide investors with a minimum rate of return and at the same time the opportunity of gaining a profit that is linked to the performance of an equity index. These properties make EIAs a popular product in the market. For modeling the equity index process and calculating the price of EIAs, as the maturity of EIAs usually is long, it is more reasonable to assume that the interest rate

and the volatility of the equity index are stochastic processes. One simple way is to apply the regime-switching model, which allows these parameters depending on the market situation. However, the valuation of derivatives in such models is challenging, especially for the strong path-dependent options such as Asian options. A trinomial tree model is introduced to provide an efficient way to solve this problem. The valuation of Asian options is studied and extended to Asian-option-related EIAs.

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### Scandinavian Actuarial Journal

Volume 2, 2010

ALBRECHER, H.; HIPPI, C.; KORTSCHAK, D. *Higher-order expansions for compound distributions and ruin probabilities with subexponential claims*. 105–135. Let  $X_i$  ( $i = 1, 2, \dots$ ) be a sequence of subexponential positive independent and identically distributed random variables. In this paper, we offer two alternative approaches to obtain higher-order expansions of the tail of  $\sum_{i=1}^n X_i$  and subsequently for ruin probabilities in renewal risk models with claim sizes  $X_i$ . In particular, these emphasize the importance of the term  $\mathbb{P}(\sum_{i=1}^n X_i > s, \max(X_1, \dots, X_n) \leq s/2)$  for the accuracy of the resulting asymptotic expansion of  $\mathbb{P}(\sum_{i=1}^n X_i > s)$ . Furthermore, we present a more rigorous approach to the often suggested technique of using approximations with shifted arguments. The cases of a Pareto type, Weibull and Lognormal distribution for  $X_i$  are discussed in more detail and numerical investigations of the increase in accuracy by including higher-order terms in the approximation of ruin probabilities for finite realistic ranges of  $s$  are given.

ASIMIT, A. V.; BADESCU, A. L. *Extremes on the discounted aggregate claims in a time dependent risk model*. 93–104. This paper presents an extension of the classical compound Poisson risk model for which the inter-claim time and the forthcoming claim amount are no longer independent random variables (rv's). Asymptotic tail probabilities for the discounted aggregate claims are presented when the force of interest is constant and the claim amounts are heavy tail distributed rv's. Furthermore, we derive asymptotic finite time ruin probabilities, as well as asymptotic approximations for some common risk measures associated with the discounted aggregate claims. A simulation study is performed in order to validate the results obtained in the free interest risk model.

BENOUARET, Z.; AÏSSANI, D. *Strong stability in a two-dimensional classical risk model with independent claims*. 83–92. In this paper, we study the strong stability of ruin probabilities in risk models. The question of stability naturally arises in risk theory since the governing parameters in these models can only be estimated with uncertainty. Moreover, in most cases there are not explicit expressions known for the ruin probabilities. Our objective is to present the applicability of the strong stability method to the bivariate classical risk model with independent claims. After clarifying the conditions to approximate the two-dimensional risk model with disturbance

parameters by the two-dimensional classical risk model, we obtain the stability inequalities with an exact computation of the constants.

DJEHICHE, B.; RINNÉ, J. *Can stocks help mend the asset and liability mismatch?* 148-160.

Stocks are generally used to provide higher returns in the long run. But the dramatic fall in equity prices at the beginning of this century, triggering large underfundings in pension plans, raised the question as to whether stocks can really help mend the asset and liability mismatch. To understand some aspects of this topical issue, we examine whether existing major equity indexes can close this gap, given the liability profile of a typical pension fund. We also compare the non-market capitalization weighted equity indexes recently introduced as Research Affiliates Fundamental Indexes<sup>®</sup> (RAFI<sup>®</sup>) with traditional market capitalization weighted equity indexes from an asset and liability management perspective. The analysis of the behavior of the solvency ratio clearly indicates that interest rate sensitive stocks have a large potential to improve the link between assets and liabilities. Compared with market capitalization weighted equity indexes, RAFI<sup>®</sup> shows a substantially better potential to mend the asset and liability mismatch, while also improving returns.

LAGERÅS, A. N. *Commutation functions under Gompertz–Makeham mortality.* 161-164. It is known, but perhaps not well-known, that when the mortality is assumed to be of Gompertz–Makeham-type, the expected remaining life-length and the commutation functions used for calculating the expected values of various types of life insurances can be expressed with an incomplete gamma function with a negative shape parameter. This is not of much use if one's software cannot calculate these values. The aim of this note is to show that one can express the commutation functions using only the exponential function, the (ordinary) gamma function and the gamma distribution function, which are all implemented in common statistical and spreadsheet software. This eliminates the need to evaluate the commutation functions and expected remaining life-length with numerical integration.

LI, S.; LU, Y. *On the maximum severity of ruin in the compound Poisson model with a threshold dividend strategy.* 136-147. We study the distribution and moments of the maximum severity of ruin in the compound Poisson risk process with a threshold dividend strategy. The distribution can be analyzed through the probability that the surplus process attains a given level from the initial surplus without first falling below zero. This note extends the results in Picard (1994) and shows that the distribution of the maximum severity of ruin can be expressed explicitly in terms of the ruin probabilities of two classical risk models with different premium rates. The moments of the maximum severity of ruin can be obtained through its distribution function.

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CHEUNG, E. C. K.; LANDRIault, D.; WILLMOT, G. E.; WOO, J.-K. *Gerber-Shiu analysis with a generalized penalty function.* 185-199. A generalization of the usual penalty function is proposed, and a defective renewal equation is derived for the Gerber-Shiu discounted penalty function in the classical risk model. This is used to derive the trivariate distribution of the deficit

at ruin, the surplus prior to ruin, and the surplus immediately following the second last claim before ruin. The marginal distribution of the last interclaim time before ruin is derived and studied, and its joint distribution with the claim causing ruin is derived.

COSSETTE, H.; MARCEAU, E.; MARRI, F. *Analysis of ruin measures for the classical compound Poisson risk model with dependence*. 221-245. In this paper, we consider an extension to the classical compound Poisson risk model. Historically, it has been assumed that the claim amounts and claim inter-arrival times are independent. In this contribution, a dependence structure between the claim amount and the interclaim time is introduced through a Farlie-Gumbel-Morgenstern copula. In this framework, we derive the integro-differential equation and the Laplace transform (LT) of the Gerber-Shiu discounted penalty function. An explicit expression for the LT of the discounted value of a general function of the deficit at ruin is obtained for claim amounts having an exponential distribution.

LEVEILLE, G.; GARRIDO, J.; WANG, Y. F. *Moment generating functions of compound renewal sums with discounted claims*. 165-184. Leveille & Garrido (2001a, 2001b) have obtained recursive formulas for the moments of compound renewal sums with discounted claims, which incorporate both, Andersen's (1957) generalization of the classical risk model, where the claim number process is an ordinary renewal process, and Taylor's (1979), where the joint effect of the claims cost inflation and investment income on a compound Poisson risk process is considered. In this paper, assuming certain regularity conditions, we improve the preceding results by examining more deeply the asymptotic and finite time moment generating functions of the discounted aggregate claims process. Examples are given for claim inter-arrival times and claim severity following phase-type distributions, such as the Erlang case.

LU, Y.; TSAI, C. C.-L. *An effective method for constructing bounds for ruin probabilities for the surplus process perturbed by diffusion*. 200-220. In this paper, we first study orders, valid up to a certain positive initial surplus, between a pair of ruin probabilities resulting from two individual claim size random variables for corresponding continuous time surplus processes perturbed by diffusion. The results are then applied to obtain a smooth upper (lower) bound for the underlying ruin probability; the upper (lower) bound is constructed from exponentially distributed claims, provided that the mean residual lifetime function of the underlying random variable is non-decreasing (non-increasing). Finally, numerical examples are given to illustrate the constructed upper bounds for ruin probabilities with comparisons to some existing ones.

NECIR, A.; BRAHIMI, B.; MERAGHNI, D. *Erratum to 'Statistical estimate of the proportional hazard premium of loss'*. 246-247. Original article in Scandinavian Actuarial Journal, Vol. 2007, no. 3, p. 147-161.

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