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## ASTIN Bulletin

40(2), 2010

AASE, K. K. *Existence and uniqueness of equilibrium in a reinsurance syndicate.* 491–517. In this paper we consider a reinsurance syndicate, assuming that Pareto optimal allocations exist. Under a continuity assumption on preferences, we show that a competitive equilibrium exists and is unique. Our conditions allow for risks that are not bounded, and we show that the most standard models satisfy our set of sufficient conditions, which are thus not restrictive. Our approach is to transform the analysis from an infinite dimensional to a finite dimensional setting.

ARTZNER, P. & EISELE, K-T. *Supervisory insurance accounting: Mathematics for provision — and solvency capital — requirement.* 569–585. This paper aims at providing a mathematical foundation for the terms of the well spread supervisory rule 'initial market value of assets must be at least equal to provision plus solvency capital'. It starts with a risk-adjusted assessment — given by a set of test probabilities — of the future cash-flows coming from a company business plan and attempts to define terms of a supervisory accounting mode. First, inspired by the idea of 'representation' of obligations by 'equivalent' assets, we define the supervisory provision (or 'liability') attached to existing obligations. This provision is market consistent according to the mathematical definition by Cheridito, Filipovic and Kupper and satisfies a property of equilibrium between supervision's wish for stress testing and management's possibility for appropriate choice of assets. The comparison between the initial market price of assets and the supervisory provision defines 'solvability' of existing obligations. In a second step the paper defines a required solvency capital as related to the level of discrepancy between assets and obligations of a company. Solvency of a business plan is defined by requiring as initial market value an additional amount over the one needed for solvability: this is the required solvency capital. A business plan with zero required solvency capital is said to have an optimal replicating asset portfolio. It is shown that — under a natural additional condition, that of a market prudent set of test probabilities — solvability of an obligation allows for solvency of a related business plan, by choice of the asset portfolio. The paper emphasizes the distinction between supervisory and market oriented accounting hinted to in the CEIOPS CP 20 consultative paper.

ATHERINO, R., PIZZINGA, A. & FERNANDES, C. *A row-wise stacking of the runoff triangle: State space alternatives for IBNR reserve prediction.* 917–946. This work deals with prediction of IBNR reserve under a different data ordering of the non-cumulative runoff triangle. The rows of the triangle are stacked, resulting in a univariate time series with several missing values. Under this ordering, two approaches entirely based on state space models and the Kalman filter are



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developed, implemented with two real data sets, and compared with two well-established IBNR estimation methods — the chain ladder and an overdispersed Poisson regression model. The remarks from the empirical results are: (i) computational feasibility and efficiency; (ii) accuracy improvement for IBNR prediction; and (iii) flexibility regarding IBNR modeling possibilities.

BJORKWALL, S., HOSSJER, O. & OHLSSON, E. *Bootstrapping the separation method in claims reserving*. 845–869. The separation method was introduced by Verbeek (1972) in order to forecast numbers of excess claims and it was developed further by Taylor (1977) to be applicable to the average claim cost. The separation method differs from the chain-ladder in that when the chain-ladder only assumes claim proportionality between the development years, the separation method also separates the claim delay distribution from influences affecting the calendar years, e.g. inflation. Since the inflation contributes to the uncertainty in the estimate of the claims reserve it is important to consider its impact in the context of risk management, too. In this paper we present a method for assessing the prediction error distribution of the separation method. To this end we introduce a parametric framework within the separation model which enables joint resampling of claim counts and claim amounts. As a result, the variability of Taylor's predicted reserves can be assessed by extending the parametric bootstrap techniques of Björkwall et al. (2009). The performance of the bootstrapped separation method and chain-ladder is compared for a real data set.

BUSSE, M., MULLER, U. & DACOROGNA, M. *Robust estimation of reserve risk*. 453–489. We tackle problems that appear in the practical application of the Mack method for the estimation of reserving risk and the bootstrapping of ultimate reserve distributions. More specifically, we design a filter for outliers and large jumps, and present a robust version of Mack's variance estimator. A combination of these guarantees a reasonable Mack and bootstrap error even for deficient data. Furthermore, a method is derived that allows us to remove the influence of fluctuations in earning patterns from the reserve risk estimate. It is thereby shown that the relation between underwriting and accident year based loss development patterns is given by a convolution. A numerically stable inversion thereof is obtained by means of a Tikhonov regularization. The reliability of the presented methods is verified with several loss triangles.

CHRISTIANSEN, M. C. & DENUIT, M. *First-Order mortality rates and safe-side actuarial calculations in life insurance*. 587–614. In this paper, we discuss how to define conservative biometric bases in life insurance. The first approach is based on cumulative hazard (or survival probabilities), the second one on the hazard itself, and the third one on the rate of increase of the hazard. The second case has been studied in the literature and the sum-at-risk plays a central role in defining safe-side requirements. The two other cases appear to be new and concepts related to sum-at-risk are defined.

CHUANG, H-L. & YU, M-T. *Pricing unemployment insurance*. 519–545. This study incorporates the survival analysis of unemployment duration into the insurance pricing framework to measure the fairly-priced premium rate for Taiwan's unemployment insurance (UI) program. Our results suggest that the fair premiums range from 0.2041% to 0.2436% under the 1999–2002 scheme and from 0.1388% to 0.1521% under the 2003–2009 scheme for various possible levels of average unemployment duration in Taiwan, and they are all lower than the current UI premium rate, 1%. This result explains in part why there is a persistent surplus in the UI program. The sensitivity analysis results indicate that the fair premium rate decreases with the hazard rate of exiting from unemployment and increases with the probability of entering into unemployment. The effect of the entering probability is found to be larger than that of the exiting probability. We also provide a wide range of systematic risk coefficient (ß) values generated from three alternative



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methods to measure its impact on fair premium rates and find that the effect of ß on premium rates is stronger under the 1999–2002 scheme than that of the 2003–2009 scheme.

CUI, J., PITT, D. & QIAN, G. *Model selection and claim frequency for workers' compensation insurance*. 779–796. We consider a set of workers' compensation insurance claim data where the aggregate number of losses (claims) reported to insurers are classified by year of occurrence of the event causing loss, the US state in which the loss event occurred and the occupation class of the insured workers to which the loss count relates. An exposure measure, equal to the total payroll of observed workers in each three-way classification, is also included in the dataset. Data are analysed across ten different states, 24 different occupation classes and seven separate observation years. A multiple linear regression model, with only predictors for main effects, could be estimated in 223 + 9 + 1 + 1 = 234 ways, theoretically more than 17 billion different possible models! In addition, one might expect that the number of claims recorded in each year in the same state and relating to the same occupation class, are positively correlated. Different modelling assumptions as to the nature of this correlation should also be considered. On the other hand it may reasonably be assumed that the number of losses reported from different states and from different occupation classes are independent. Our data can therefore be modelled using the statistical techniques applicable to panel data and we work with generalised estimating equations (GEE) in the paper. For model selection, Pan (2001) suggested the use of an alternative to the AIC, namely the quasi-likelihood under independence model criterion (QIC), for model comparison. This paper develops and applies a Gibbs sampling algorithm for efficiently locating, out of the more than 17 billion possible models that could be considered for the analysis, that model with the optimal (least) QIC value. The technique is illustrated using both a simulation study and using workers' compensation insurance claim data.

DE ALBA, E., ZUNIGA, J. & RAMIREZ CORZO, M. *Measurement and transfer of catastrophic risks*. 547–568. When analyzing catastrophic risk, traditional measures for evaluating risk, such as the probable maximum loss (PML), value at risk (VaR), tail-VaR, and others, can become practically impossible to obtain analytically in certain types of insurance, such as earthquake, and certain types of reinsurance arrangements, specially non-proportional with reinstatements. Given the available information, it can be very difficult for an insurer to measure its risk exposure. The transfer of risk in this type of insurance is usually done through reinsurance schemes combining diverse types of contracts that can greatly reduce the extreme tail of the cedant's loss distribution. This effect can be assessed mathematically. The PML is defined in terms of a very extreme quantile. Also, under standard operating conditions, insurers use several 'layers' of non proportional reinsurance that may or may not be combined with some type of proportional reinsurance. The resulting reinsurance structures will then be very complicated to analyze and to evaluate their mitigation or transfer effects analytically, so it may be necessary to use alternative approaches, such as Monte Carlo simulation methods. This is what we do in this paper in order to measure the effect of a complex reinsurance treaty on the risk profile of an insurance company. We compute the pure risk premium, PML as well as a host of results: impact on the insured portfolio, risk transfer effect of reinsurance programs, proportion of times reinsurance is exhausted, percentage of years it was necessary to use the contractual reinstatements, etc. Since the estimators of quantiles are known to be biased, we explore the alternative of using an Extreme Value approach to complement the analysis.

FREES, E. J., MEYERS, G. & CUMMINGS, A. D. *Dependent multi-peril ratemaking model*. 699–726. This paper considers insurance claims that are available by cause of loss, or peril.



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Using this multi-peril information, we investigate multivariate frequency and severity models, emphasizing alternative dependency structures. Although dependency models may be used for many risk management strategies, we focus on ratemaking. Motivation for this research comes from homeowners insurance and so, for the frequency portion, we consider binary response models. Specifically, we examine several multivariate binary regression models that have appeared in the biomedical literature, focusing on a dependence ratio model. For multivariate severity, we use Gaussian copulas to represent dependencies among gamma regressions. We calibrate competing models based on a representative sample of over 400,000 records and validate them using a held-out sample of over 350,000 records. We find that methods that allow for cross-dependencies among perils provide important economic value in pricing.

HO, H-C., YANG, S. S. & LIU, F-I. *Evaluating quantile reserve for equity-linked insurance in a stochastic volatility model: Long vs. short memory.* 669–698. This paper evaluates the long-term risk for equity-linked insurance products. We consider a specific type of equity-linked insurance product with guaranteed minimum maturity benefits (GMMBs), and assume that the underlying equity follows the stochastic volatility model which allows the return's latent volatility component to be short- or long-memory. The explicit form of the quantile reserve or the Value at Risk and its confidence intervals are derived for both the long-memory and short-memory stochastic volatility models. To illustrate the effect of long-memory volatility, we use the S&P 500 index as an example of linked equity. Simulation studies are performed to examine the accuracy of the quantile reserve and to demonstrate the consequence of low coverage probability if model misspecification takes place. The empirical results show that the confidence interval of quantile reserve could be severely underestimated if the long-memory effect in equity volatility is ignored.

HURLIMANN, W. *Analytical pricing of the unit-linked endowment with guarantees and periodic premiums.* 631–653. We consider the unit-linked endowment with guarantee and periodic premiums, where at each premium payment date the insurance company invests a certain fraction of the premium into a risky reference portfolio. In the dual random environment of stochastic interest rates with deterministic volatilities and mortality risk, and for a fixed guarantee, simple analytical lower and upper bounds for the fair periodic premium are explicitly derived. We also consider contracts with guaranteed minimum benefits that vary over time and we obtain tight lower and upper bounds for both fair periodic premiums and guaranteed minimum benefits that increase over time. The numerical illustrations of our results reveal that the analytical bounds are very tight. Moreover, the simple, fast and very reliable analytical numerical calculations with controlled accuracy avoid time consuming Monte Carlo calculations and are almost always preferred by practitioners. Some analytical closed-form solutions for one- and two-year maturity dates are also stated.

JOSHI, M. & PITT, D. *Fast sensitivity computations for Monte Carlo valuation of pension funds.* 655–667. Sensitivity analysis, or so-called 'stress-testing', has long been part of the actuarial contribution to pricing, reserving and management of capital levels in both life and non-life assurance. Recent developments in the area of derivatives pricing have seen the application of adjoint methods to the calculation of option price sensitivities including the well-known 'Greeks' or partial derivatives of option prices with respect to model parameters. These methods have been the foundation for efficient and simple calculations of a vast number of sensitivities to model parameters in financial mathematics. This methodology has yet to be applied to actuarial problems in insurance or in pensions. In this paper we consider a model for a defined benefit pension scheme and use adjoint methods to illustrate the sensitivity of fund valuation results



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to key inputs such as mortality rates, interest rates and levels of salary rate inflation. The method of adjoints is illustrated in the paper and numerical results are presented. Efficient calculation of the sensitivity of key valuation results to model inputs is useful information for practising actuaries as it provides guidance as to the relative ultimate importance of various judgments made in the formation of a liability valuation basis.

MALINOVSKII, V. K. *Competition-originated cycles and insurance strategies*. 797–843. An insurance company entering the property and liability insurance market at the high point of the insurance cycle may decide to slash premiums to gain an advantageous market share. Such aggressive intrusion may call forth a concerted industry response, producing a severe decline in the insurance market price. This can ruin some companies, and agrees with the observation that the insurance cycles are correlated with clustered insolvencies. This paper addresses a quantitative analysis of competition-originated cycles; it explores an interplay of rational aggressive and defensive strategies in the multi-period Lundberg-type controlled risk model.

NYRHINEN, H. *Economic factors and solvency*. 889–915. We study solvency of insurers in a practical model where in addition to basic insurance claims and premiums, economic factors like inflation, real growth and returns on the investments affect the capital developments of the companies. The objective is to give qualitative descriptions of risks by means of crude estimates for finite time ruin probabilities. In our setup, the economic factors have a dominant role in the estimates. In addition to this theoretical view, we will focus on applied interpretations of the results by means of discussions and examples.

REN, J. *Recursive formulas for compound phase distributions: Univariate and bivariate cases*. 615–629. We first present a simple matrix-based recursive formula for calculating the distribution function of compound phase-type random variables. Then we extend the results to the case when the number of claims follows a bivariate matrix negative binomial (BMNB) distribution detailed herein. Further, extending the results in Hipp (2006), we provide speedy recursive formulas for both the univariate and the bivariate models when the claim sizes follow discrete phase-type distributions. Numerical examples are provided.

RIEGEL, U. *On fire exposure rating and the impact of the risk profile type*. 727–777. We analyze fire exposure rating for three types of risk profiles: policy profiles, top location profiles and location profiles. Location profiles offer more detailed information than top location profiles, which in turn are better than policy profiles. We prove criteria to ensure that a better quality of risk profile leads to a lower price. These criteria are discussed with respect to standard exposure rating and an alternative method called 'burning cost-adjusted exposure rating', where the loss ratio is adjusted by means of the burning cost of a low reference layer. Further, we introduce a family of analytic exposure curves, the so-called EP exposure curves. These curves are useful for practical application, since the criteria given in this paper can be checked easily for exposure curves that can be approximated by EP exposure curves. This is of particular interest for discrete exposure curves. Finally, we apply the results to the MBBEFD exposure curves.

SALZMANN, R. & WUTHRICH, M. V. *Cost-of-Capital margin for a general insurance liability runoff*. 415–451. Under new solvency regulations, general insurance companies need to calculate a risk margin to cover possible shortfalls in their liability runoff. A popular approach for the calculation of the risk margin is the so-called cost-of-capital approach. A comprehensive cost-of-capital approach involves the consideration of multiperiod risk measures.



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Because multiperiod risk measures are rather complex mathematical objects, various proxies are used to estimate this risk margin. Of course, the use of proxies and the study of their quality raises many questions, see IAA position paper [8]. In the present paper we provide a first discourse on multiperiod solvency considerations for a general insurance liability runoff. Within a chain ladder framework, we derive analytic formulas for the risk margin which allow to compare the comprehensive approach to the different proxies used in practice. Moreover, a case study investigates and answers questions raised in [8].

VERRALL, R., NIELSEN, J. P. & JESSEN, A. H. *Prediction of RBNS and IBNR claims using claim amounts and claim count.* 871–887. A model is proposed using the run-off triangle of paid claims and also the numbers of reported claims (in a similar triangular array). These data are usually available, and allow the model proposed to be implemented in a large variety of situations. On the basis of these data, the stochastic model is built from detailed assumptions for individual claims, but then approximated using a compound Poisson framework. The model explicitly takes into account the delay from when a claim is incurred and to when it is reported (the IBNR delay) and the delay from when a claim is reported and to when it is fully paid (the RBNS delay). These two separate sources of delay are estimated separately, unlike most other reserving methods. The results are compared with those of the chain ladder technique.

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BARGÈS, M., COSSETTE, H., LOISEL, S. & MARCEAU, E. *On the moments of aggregate discounted claims with dependence introduced by a FGM copula.* 215–238. In this paper, we investigate the computation of the moments of the compound Poisson sums with discounted claims when introducing dependence between the interclaim time and the subsequent claim size. The dependence structure between the two random variables is defined by a Farlie-Gumbel-Morgenstern copula. Assuming that the claim distribution has finite moments, we give expressions for the first and the second moments and then we obtain a general formula for any mth order moment. The results are illustrated with applications to premium calculation and approximations based on moment matching methods.

CABRAS, S., CASTELLANOS, M. E. *A Bayesian approach for estimating extreme quantiles under a semiparametric mixture model.* 87–106. In this paper we propose an additive mixture model, where one component is the Generalized Pareto distribution (GPD) that allows us to estimate extreme quantiles. GPD plays an important role in modeling extreme quantiles for the wide class of distributions belonging to the maximum domain of attraction of an extreme value model. One of the main difficulty with this modeling approach is the choice of the threshold u, such that all observations greater than u enter into the likelihood function of the GPD model. Difficulties are due to the fact that GPD parameter estimators are sensible to the choice of u. In this work we estimate u, and other parameters, using suitable priors in a Bayesian approach. In particular, we propose to model all data, extremes and non-extremes, using a semiparametric model for data below u, and the GPD for the exceedances over u. In contrast to the usual estimation techniques for u, in this setup we account for uncertainty on all GPD parameters, including u, via their posterior distributions. A Monte Carlo study shows that posterior credible intervals also have frequentist coverages. We further illustrate the advantages of our approach on two applications from insurance.



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CAIRNS, A. J. G., BLAKE, D., DOWD, K., COUGHLAN, G. D. & KHALAF-ALLAH, M. *Bayesian stochastic mortality modelling for two populations*. 29–59. This paper introduces a new framework for modelling the joint development over time of mortality rates in a pair of related populations with the primary aim of producing consistent mortality forecasts for the two populations. The primary aim is achieved by combining a number of recent and novel developments in stochastic mortality modelling, but these, additionally, provide us with a number of side benefits and insights for stochastic mortality modelling. By way of example, we propose an Age-Period-Cohort model which incorporates a mean-reverting stochastic spread that allows for different trends in mortality improvement rates in the short-run, but parallel improvements in the long run. Second, we fit the model using a Bayesian framework that allows us to combine estimation of the unobservable state variables and the parameters of the stochastic processes driving them into a single procedure. Key benefits of this include dampening down of the impact of Poisson variation in death counts, full allowance for parameter uncertainty, and the flexibility to deal with missing data. The framework is designed for large populations coupled with a small sub-population and is applied to the England & Wales national and Continuous Mortality Investigation assured lives males populations. We compare and contrast results based on the two-population approach with single-population results.

DENUIT, M., EECKHOUDT, L. & MENEGATTI, M. *A note on subadditivity of zero-utility premiums*. 239–250. Many papers in the literature have adopted the expected utility paradigm to analyze insurance decisions. Insurance companies manage policies by growing, by adding independent risks. Even if adding risks generally ultimately decreases the probability of insolvency, the impact on the insurer's expected utility is less clear. Indeed, it is not true that the risk aversion toward the additional loss generated by a new policy included in an insurance portfolio always decreases with the number of contracts already underwritten. The present paper derives conditions under which zero-utility premium principles are subadditive for independent risks. It is shown that subadditivity is the exception rather than the rule: the zero-utility premium principle generates a superadditive risk premium for most common utility functions. For instance, all completely monotonic utility functions generate superadditive zero-utility premiums. The main message of the present paper is thus that the zero-utility premium for a marginal policy is generally not sufficient to guarantee the formation of insurance portfolios without additional capital.

KLEINOW, T. *Pension fund management and conditional indexation*. 61–86. Conditional indexation offers a middle way between defined benefit and defined contribution pension schemes. In this paper, we consider a fully-funded pension scheme with conditional indexation. We show how the pension fund can be managed to reduce the risks associated with promised pension benefits when declared benefits are adjusted regularly during the working life. In particular, we derive an investment strategy that provides protection against underfunding at retirement and which is self-financing on average. Our results are illustrated in an extensive simulation study.

KOCH, I. & DE SCHEPPER, A. *Measuring comonotonicity in M-dimensional vectors*. 191–213. In this contribution, a new measure of comonotonicity for m-dimensional vectors is introduced, with values between zero, representing the independent situation, and one, reflecting a completely comonotonic situation. The main characteristics of this coefficient are examined, and the relations with common dependence measures are analysed. A sample-based version of the comonotonicity coefficient is also derived. Special attention is paid to the explanation of the accuracy of the convex order bound method of Goovaerts, Dhaene et al. in the case of cash flows with Gaussian discounting processes.



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MARTINEZ MIRANDA, M. D., NIELSEN, B., NIELSEN, J. P. & VERRALL, R. *Cash flow simulation for a model of outstanding liabilities based on claim amounts and claim numbers.* 107–129. In this paper we develop a full stochastic cash flow model of outstanding liabilities for the model developed in Verrall, Nielsen and Jessen (2010). This model is based on the simple triangular data available in most non-life insurance companies. By using more data, it is expected that the method will have less volatility than the celebrated chain ladder method. Eventually, our method will lead to lower solvency requirements for those insurance companies that decide to collect counts data and replace their conventional chain ladder method.

PAPACHRISTOU, D. *Statistical analysis of the spreads of catastrophe bonds at the time of issue.* 251–273. In this paper the catastrophe bond prices, as determined by the market, are analysed. The limited published work in this area has been carried out mainly by cat bond investors and is based either on intuition, or on simple linear regression on one factor or on comparisons of the prices of cat bonds with similar features. In this paper a Generalised Additive Model is fitted to the market data. The statistical significance of different factors which may affect the cat bond prices is examined and the effect of these factors on the prices is measured. A statistical framework and analysis could provide insight into the cat bond pricing and could have applications among other things in the construction of a cat bond portfolio, cat bond price indices and in understanding changes of the price of risk over time.

PAULSEN, J. & STUBO, K. *On maximum likelihood and pseudo-maximum likelihood estimation in compound insurance models with deductibles.* 1–28. Non-life insurance payouts consist of two factors: claimsizes and claim frequency. When calculating e.g. next years premium, it is vital to correctly model these factors and to estimate the unknown parameters. A standard way is to separately estimate in the claimsize and the claim frequency models.

Often there is a deductible with each single claim, and this deductible can be quite large, particularly in inhomogeneous cases such as industrial fire insurance or marine insurance. Not taking the deductibles into account can lead to serious bias in the estimates and consequent implications when applying the model.

When the deductibles are nonidentical, in a full maximum likelihood estimation all unknown parameters have to be estimated simultaneously. An alternative is to use pseudo-maximum likelihood, i.e. first estimate the claimsize model, taking the deductibles into account, and then use the estimated probability that a claim exceeds the deductible as an offset in the claim frequency estimation. This latter method is less efficient, but due to complexity or time considerations, it may be the preferred option.

In this paper we will provide rather general formulas for the relative efficiency of the pseudo maximum likelihood estimators in the i.i.d. case. Two special cases will be studied in detail, and we conclude the paper by comparing the methods on some marine insurance data.

TAYLOR, G. *Maximum likelihood and estimation efficiency of the chain ladder.* 131–155. The chain ladder is considered in relation to certain recursive and non-recursive models of claim observations. The recursive models resemble the (distribution free) Mack model but are augmented with distributional assumptions. The nonrecursive models are generalisations of Poisson cross-classified structure for which the chain ladder is known to be maximum likelihood. The error distributions considered are drawn from the exponential dispersion family.



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Each of these models is examined with respect to sufficient statistics and completeness (Section 5), minimum variance estimators (Section 6) and maximum likelihood (Section 7). The chain ladder is found to provide maximum likelihood and minimum variance unbiased estimates of loss reserves under a wide range of recursive models. Similar results are obtained for a much more restricted range of non-recursive models.

These results lead to a full classification of this paper's chain ladder models with respect to the estimation properties (bias, minimum variance) of the chain ladder algorithm (Section 8).

ZHAO, L. & ZHU, W. *Ambiguity aversion : a new perspective on insurance pricing*. 157–189. This paper intends to develop a feasible framework which incorporates ambiguity aversion into the pricing of insurance products and investigate the implications of ambiguity aversion on the pricing by comparing it with risk aversion. As applications of the framework, we present the closed-form pricing formulae for some insurance products appearing in life insurance and property insurance. Our model confirms that the effects of ambiguity aversion on the pricing of insurance do differ from those of risk aversion. Implications of our model are consistent with some empirical evidences documented in the literature. Our results suggest that taking advantage of natural hedge mechanism can help us control the effects of model uncertainty.

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## Australian Actuarial Journal

16(2), 2010

AVANZI, B. *What is it that makes the Swiss annuitise? A description of the Swiss retirement system*. 135–162. The Swiss model of retirement savings and benefits distinguishes itself in several aspects. The system is successful in encouraging substantial savings, which are exonerated from tax and guaranteed. The associated market risk is not transferred to the individuals. From an international perspective it is extraordinary that more than half of the Swiss who retire choose to annuities their capital at retirement. In addition, not only does the retirement scheme offer annuity benefits at retirement, but it also offers annuity benefits on disability and death. In this paper, the Swiss old age security system is described with an emphasis on retirement benefits, giving some insights as to what in Switzerland could explain why the so-called 'annuity puzzle' is not observed. This question is of relevance to countries that wish to encourage annuitisation as a powerful tool to deal with the longevity risk of their elder population. Keywords: annuity puzzle; pensions; Switzerland.



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KIM, C., LIM, J. & SHIM, G. *Exponential reserves of insurance contracts under a jump-diffusion*. 109–133. In terms of the liability process, we consider a collective risk model that generates claims in portfolios of insurance policies. We also consider a financial market for investments, under the assumption that the risky asset process follows a geometric Brownian motion i.e. the model for assets and liabilities follows a jump-diffusion process. We calculate the indifference premiums and the exponential reserves that maximise the final expectation of the portfolio values, and we also show that the indifference premiums are calculated under the certainty equivalence principle. It is interesting to note that the exponential reserves under the prospective method constitute the difference between the current value of the future certainty equivalent of benefits and the present value of the future certainty of premiums. Similarly, using the retrospective method, the exponential reserves consititute the difference between the accumulated value of the past indifference premiums and the current value of the certainty equivalent of past benefit payments. Keywords: Indifference premiums; Exponential reserves; Certainty equivalence principle; Jump-division process; Prospective method; Retrospective method.

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Geneva Papers on Risk and Insurance

35(Supplement 1), 2010

HSU, W-Y. & PETCHSAKULWONG, P. *The impact of corporate governance on the efficiency performance of the Thai non-life insurance industry*. S28–S49. This paper examines the relation between corporate governance and efficiency performance of public non-life insurance companies in Thailand over the period 2000–2007. Data envelopment analysis is used to compute an insurer's efficiency performance including technical, allocative, cost, and revenue efficiency. We then employ truncated bootstrapped regression to test the relation between efficiency performance and corporate governance. The results show that the characteristics of corporate governance influence the efficiency performance of non-life insurers. In particular, board independence, diligence, and firm size have a positive impact on the efficiency performance of the Thai non-life insurance companies. However, audit committee size, diligence, divergence between voting rights and cash flow rights, board tenure, board age, as well as board ownership have a negative impact on the efficiency performance. Finally, our empirical evidence also indicates that there is an unclear relation between an insurer's efficiency performance and the board size, the proportion of financial expertise on an audit committee, and the board compensation.

ISHIHARA, K. *Contributing to the global debate on climate change - a view from Asia: a retrospective report on the 37th General assembly in Zurich (June 2010)*. S92–S99. Retrospective report on the 37th General assembly in Zurich (June 2010).

LEE, K. & SUNG, J. *A new Korean defined contribution plan framework to enhance retirement income security: combining lifecycle funds with compulsory annuitisation*. S50–S67. In this paper, the intension is to construct a new Korean defined contribution operation structure that better



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meets retirement income security by integrating accumulation and payout phases. For this, two approaches are compared: a lump sum withdrawal programme supported by a principal preservation fund (i.e. current approach), and the combination of compulsory annuitisation with lifecycle funds (i.e. alternative approach). We set benchmark incomes, annuity incomes from the immediate life annuity policy, purchasable at retirement with the accumulated assets of lifecycle funds. The above two approaches are then assessed in terms of the probability of shortfall employed here to measure the longevity risk, at a Value-at-Risk of 50, 75 and 95 per cent, respectively. Consequently, it is shown that the alternative approach provides better retirement income security than the current approach.

LEE, S-J., KWON, S. I. & CHUNG, S. Y. *Determinants of household demand for insurance: the case of Korea.* S82–S91. This article analyses the effect of household characteristics on the demand for insurance using consumer survey data in Korea. Using Tobit analysis, we have found that the self-employed have a stronger demand for insurance than salaried workers, and that residents of small cities and rural areas purchase more protection-type insurance than metropolitan residents. Demand for insurance can differ depending on employment type and residential area, which has not been examined in previous studies. We have also found that there is a curvilinear relationship between age and demand for insurance. Results suggest that households with different demographic characteristics choose different risk-reducing instruments.

LI, C-S., LIN, C. H., LIU, C-C. & VENEZIAN, E. *Pricing effectiveness and regulation: an examination of premium rating in Taiwan automobile insurance.* S68–S81. This paper examines premium determination of voluntary automobile insurance policies and risk classification under Taiwan's heavily regulated rating system. On the basis of a unique data set, we investigate the appropriateness of the official one-size-fits-all rating formula for insurers by calculating an actual premium, a pure premium in terms of incurred loss, and a loading factor to account for different insurance coverage types. Empirical evidence indicates that there are large discrepancies between average actual premiums and average pure premiums, requiring large loading factors. The official formula captures the regular loss pattern but not excess claims, due to biased claims' behaviour. In addition, average loss ratios for all coverage types are closely correlated and profitability is high.

PARK, S. C., LEMAIRE, J. & CHUA, C. T. *Is the design of bonus-malus systems influenced by insurance maturity or national culture? Evidence from Asia.* S7–S27. Most Asian countries have adopted bonus-malus systems (BMS) in automobile insurance. We evaluate the toughness towards consumers of 16 Asian BMS and its correlation with cultural and economic variables. We use principal components analysis to define a Maturity Index of insurance markets and find supporting evidence for a conjecture that, as markets become more mature and policy-holders more sophisticated, countries adopt tougher BMS. In addition, we find, using regression analysis, that using a Common Law legal system is a crucial factor in BMS design. Cultural variables, such as uncertainty avoidance, also influence BMS.

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BERRY-STÖLZLE, T. R., HOYT, R. E. & WENDE, S. *Erratum: Successful business strategies for insurers entering and growing in emerging markets.* 349–359. In the version of this article that



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was initially published in Vol 35, issue 1 (2010) pp. 110–129, the authors' amendments were not correctly implemented. Corrected tables 1–5.

ELING, M. & LUHNEN, M. *Frontier efficiency methodologies to measure performance in the insurance industry: overview, systematization, and recent developments*. 217–265. The purpose of this paper is to provide an overview on frontier efficiency measurement in the insurance industry, a topic of great interest in the academic literature during the last several years. We provide a comprehensive survey of 95 studies with a special emphasis on innovations and recent developments. We review different econometric and mathematical programming approaches to efficiency measurement in insurance and discuss the choice of input and output factors. Furthermore, we categorise the 95 studies in 10 different areas of application and discuss selected results. While there is a broad consensus with regard to the choice of methodology and input factors, our review reveals large differences in output measurement. Significant need for future research can be identified, for example, with regard to analysis of organisational forms, market structure and risk management, especially in the international context.

HAN, L., LI, D., MOSHIRIAN, F. & TIAN, Y. *Insurance development and economic growth*. 183–199. This paper investigate the relationship between insurance development and economic growth by employing GMM models on a dynamic panel data set of 77 economies for the period 1994–2005. Insurance density is used to measure the development of insurance. Controlled by a simple conditioning information set and a policy information set, we can draw a conclusion that insurance development is positively correlated with economic growth. The sample is then divided into developed and developing countries. For the developing economies, the overall insurance development, life insurance and non-life insurance development play a much more important role than they do for the developed economies.

LEE, C-C., HSU, Y-C. & LEE, C-C. *An empirical analysis of non-life insurance consumption stationarity*. 266–289. This paper explores whether the stationarity hypothesis of non-life insurance consumptions is supported during the period 1979–2005 for 31 countries. The stationarity of insurance consumption has important implications for modelling and forecasting insurance activities. On a global scale, this paper first implements the recent panel seemingly unrelated regressions augmented Dickey-Fuller root test, which allows us to account for possible cross-country effects and to identify how many and which countries of the panel contain a unit root. The main conclusion is that whether non-life insurance consumptions are stationary or not will be affected by different regions and their levels of development. Overall, our empirical results illustrate that non-life insurance consumptions in these countries are a mixture of stationary (integrated of order zero) and non-stationary (integrated of order one) processes. Higher risk aversion, lower income level and lower level of insurance market development may lead to non-stationarity. Finally, for the estimated half-lives of Africa, the degrees of mean reversion are greater than those for Europe and America.

MARANO, P. *Reinsurance intermediaries: a comparison of the EU and U.S. regulatory approach*. 200–216. Directive 2002/92/EC on insurance mediation holds very few provisions on reinsurance intermediaries whose discipline is in the hands, in large part, of each Member State. This lack of harmonized rules is consistent with the transnational nature of the reinsurance market. The purpose of this investigation is to highlight possible adverse effects of this lack of harmonisation by providing, at the same time, useful suggestions to counteract them for the forthcoming launch of the procedure of revising the Directive 2002/92/EC. The method of investigation used consists



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in the comparison of the current EU rules on reinsurance intermediaries with those applicable in the U.S. that are more detailed, while regulating intermediaries performing similar functions, in a highly sophisticated market that has the same need of protection as the European one.

NEKTARIOS, M. & BARROS, C. P. *A Malmquist index for the Greek insurance industry.* 309–324. The objective of this paper is to estimate the effects of deregulation after the implementation of the Third Insurance Directive in the Greek insurance market. Efficiency and productivity measures are estimated by means of data envelopment analysis, applied to a sample of almost all Greek insurance companies, for the product 1994–2003. The companies are separated into three groups: life, non-life and mixed insurance companies, and a Malmquist index is estimated for each group. The Malmquist index is decomposed into technical efficiency change (pure technical and scale efficiency) and technological change. It is found that the life sector experienced an average annual productivity growth of 16.1 per cent, the non-life sector had a rate of 6.5 per cent and the group of mixed insurance companies had the lowest productivity of 3.3 per cent.

SATO, M. & SEKI, M. *Sustainable business, sustainable planet - a Japanese insurance perspective.* 325–335. Climate change is a major issue of unprecedented proportions that will have far-reaching impacts on society and the economy, as the phenomenon will trigger an increase in flooding, drought and other natural disasters. For the insurance industry, climate change poses a great risk to management because an increase in natural disasters will lead to an increase in insurance payments. Taking their advantage as insurers, insurance companies should contribute toward the realisation of a low-carbon society and a climate-resilient society through their core business by means of mitigation and adaptation strategies. To achieve this goal, education is paramount, as it is the foundation of all our endeavours. For a business to grow in a sustainable manner, it is vital that the society itself develops in a sustainable manner. All organisations and individuals must embody the spirit of sustainable development in their own activities.

WANG, M-Y., WEN, C.-H. & LAN, L. W. *Modelling different types of bundled automobile insurance choice behaviour: the case of Taiwan.* 290–308. Automobile insurance policies (AIPs) are typically offered by the insurers in different bundled formats and some of which may be highly similar. This study proposed a two-component modelling system, which consists of choice of physical damage coverage and choice of non-physical damage coverage. Both multinomial logit (MNL) and paired combinatorial logit (PCL) models are attempted to explain the choice behaviours of AIP alternatives. The proposed models are tested with a large data set drawn from a Taiwanese non-life insurance company. It is found that the PCL model is structurally superior to the MNL model in analysing the choice of physical damage bundled AIP alternatives. In the context of non-physical damage coverage choice, however, the assumptions from the MNL model hold, suggesting that the use of PCL model is not required. Based on our estimation results, the insurance providers can develop marketing strategies to refine their existing AIPs or to develop new AIPs to better serve their customers.

WILKINS, M. *The need for a multi-level approach to climate change - an Australian insurance perspective.* 336–348. Insurance is all about risk management and risk mitigation. A significant component of this risk equation is an ability to manage the variability of weather events. Climate modelling has shown that it only takes small changes in the mean climate to generate large changes in extreme weather. This has profound implications for the insurance industry, because a less-predictable climate impacts the industry's capacity to accurately calculate and price products. The insurance industry's response to climate change will determine the shape of the industry for



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decades to come. However, insurance companies acting alone, or even collectively, will have only limited impact in achieving success over the long term. This paper outlines a multi-level approach required by the insurance industry to make a real and lasting difference, including engaging governments; assisting and educating communities to be more aware and resilient; incentivising customers through advocacy, product innovation and appropriate product offerings; and leading by example and providing employees with the education and tools to facilitate action both at work and at home.

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ABRAHAM, K. S. *Lessons learned from the history of corporate liability insurance in the United States Guest editorial*. 364–368.

BRUGGEMAN, V., FAURE, M. G. & FIORE, K. *The government as reinsurer of catastrophe risks?* 369–390. Compensation for victims of catastrophes is a hot topic in many countries today. Consequently, the legislator is increasingly intervening in the catastrophe insurance market in order to stimulate its functioning. Various forms of public-private partnerships have hence developed, although law and economics scholarship has differing views on this type of government intervention. The aim of this paper is to add to that debate by, on the one hand, discussing a few specific cases where the government acts as a reinsurer of last resort or as a primary insurer, and by, on the other hand, confronting these practical examples with five main conditions that would have to be fulfilled to make government intervention efficient—or at least as little disruptive as possible: market failure, the charging of risk-based premiums, the stimulation of existing market solutions, the freedom to choose for State reinsurance and the temporary character.

CASTELLANO, G. *Governing ignorance: emerging catastrophic risks - industry responses and policy frictions*. 391–415. The growing interconnections between people, markets and networks together with the development of new technologies have increased the frequency and impact of large-scale disasters around the globe. Many of these events, defined as emerging catastrophic (or systemic) risks, have no previous record. At the same time there is a strong probability that their frequency and impact will increase in the future. This paper takes a governance perspective by assuming that policy actions should be designed to cope with ignorance and large-scale losses, being the primary features characterising such emerging catastrophic risks. Precisely, the governance activity should aim both at expanding the industries' capacity to absorb losses and at acquiring more information about frequency and impact of such losses. However, it appears that some solutions may conflict with policy objectives. In particular, direct governmental interventions to compensate victims and stringent antitrust policy goals might block the development of a market for first-party property insurance for emerging systemic risks. This paper elicits crucial points that require further elaboration by policy-makers, thereby stressing the importance of providing a workable legal definition of such line of risk that embraces the precautionary principle.

NEKTARIOS, M. *Deregulation, insurance supervision and guaranty funds*. 452–468. The objective of this article is twofold: first, to present a holistic approach to insurance regulation and, second,



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to put forward the proposition that the establishment of guaranty funds will facilitate the effectiveness of the supervisory authorities in the European insurance markets, which will go through the consolidation process. Consolidation will materialise by means of mergers and acquisitions, exits and bankruptcies. It is argued that consumer expectations, intensified competition and the convergence of financial and insurance markets require the establishment of guaranty funds in all Member States of the European Union, in order to deal with the expected increased rate of insurer insolvencies. Such an evolution will provide supervisory authorities with more degrees of freedom in removing earlier impaired insurers from the market, instead of waiting and exacerbating the eventual insolvency deficits. The argument is that, in addition to protecting the victims of insolvencies, such an arrangement is optimal as an insurance device, which will increase consumer confidence and market stability.

OUTREVILLE, J. F. *The Geneva risk and insurance review 2009: In quest of behavioural insurance*. 484–497. The purpose of this article is to review and summarize the papers published in The Geneva Risk and Insurance Review in 2009. Asymmetric information, adverse selection and moral hazard are the keywords in several papers in this volume. These papers highlight how applied research in insurance could help understand the behaviour of policy-holders and have important implications for the insurance industry. This is an important issue in insurance and the papers summarized in this article raise some interesting potential empirical research questions and call for a behavioural research approach applied to insurance, a field that could be defined as behavioural insurance.

SCHWARZE, R. & HOFFMEISTER, O. *The winding road to industrial safety: evidence on the effects of environmental liability on accident prevention in Germany*. 416–434. The German Environmental Liability Law (ELL) of 1991 has introduced far-reaching civil liability for environmental damages with the aim of increasing firms' efforts to prevent accidents. Previous studies find poor evidence that this goal has actually been achieved. One and a half decades after the introduction of that law, we undertake a new attempt to investigate the impact of the ELL on accident prevention. Our analysis is based on annual data on the number of environmental accidents per year, reported to the monitoring agency ZEMA, and the risk premium imposed by a large German insurer on environmental liability insurance (ELI). Examining the relationship between the ELI premium and accident prevention, we are able to model the dynamics of the adjustment process induced by the ELL. According to our results, the average number of environmental accidents per year has decreased from 35 before to 22 after the reform.

WANG, Y. *Analysing insurer rating transitions with different economic and industry cycles*. 435–451. Changes in insurer ratings reflect changes in their financial strength. For the first time, unconditional and conditional matrices for U.S. property-liability insurer ratings during the period 1995–2006 are estimated and compared across different economic and industry cycles. Findings indicate that the distribution of insurer rating changes varies across different economic and industry cycles and insurers usually perform better when economic and industry conditions are favourable. Regression analyses generally confirm this relationship. Our results give a new perspective for regulators, consumers and investors to measure and manage insurer financial risks across time.

YUNG-MING, S. *Derivative hedging and insurer solvency: evidence from Taiwan*. 469–483. Using company-level panel data (2001–2003), this paper empirically examines whether Taiwanese insurers' use of derivatives for hedging purposes is significantly related to their solvency (as measured by solvency ratio). Contrary to the public's perception that firms with derivative



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programmes have a higher level of solvency if derivatives are employed for hedging purposes, our results indicate that life insurers' derivative hedging generally is not associated with solvency, while non-life insurers using derivative hedging have a lower level of solvency.

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ARMSTRONG, J. & PAOLUCCI, F. *Risk equalisation in Ireland and Australia: a simulation analysis to compare outcomes.* 521–538. Risk equalisation has been implemented in a number of countries as a means of providing explicit risk-adjusted transfers between health insurance undertakings to improve efficiency within the health insurance market, and make health insurance affordable. Two such countries are Australia and Ireland. In this article, a simulation exercise is carried out to compare the effectiveness of the two countries' risk equalisation schemes in meeting the policy objectives of encouraging insurers to be efficient and discourage them from engaging in risk selection. The results of the analysis show that the Australian scheme is less effective than the Irish scheme in reducing the incentive for risk selection and in encouraging insurers to be efficient. The results provide evidence that direct standardisation mechanisms (as used in Ireland) can lead to superior outcomes as compared to indirect standardisation mechanisms (as used in Australia) in terms of promoting efficiency and deterring risk selection.

BERNSTEIN, D. *Health care reinsurance and insurance reform in the United States: a simulation model.* 568–580. This paper uses data from the Medical Expenditures Panel Survey, a U.S. health care survey, to simulate the impact of reinsurance on insured health care expenditures for different cohorts. The paper concludes that reinsurance would not eliminate potential risk selection by insurers and, even with reinsurance, specific cohorts would have trouble obtaining affordable insurance unless reinsurance was accompanied by significant changes to U.S. insurance laws including the adoption of guarantee issue requirements and the abolition of underwriting based on health status or pre-existing conditions. The simulation model reveals that the impact of reinsurance on insurance expenditures is larger for older cohorts than for younger cohorts.

HADDAD, G. K. & ANBAJI, M. ZI. *Analysis of adverse selection and moral hazard in the health insurance market of Iran.* 581–599. This paper aims to estimate a demand model for health insurance and medical care in Iran, in the presence of heterogeneous and latent health status of individuals; moreover it tests the asymmetry of information in the health insurance market. Our data set has been taken from the Households' expenditures survey (2006) of Iran. Parameters of the model are estimated by the Generalized Method of Moments (GMM) and the presence of asymmetric information (adverse selection and moral hazard) is tested by a non-parametric econometric method. The insurance categories and the statistical distribution of individual's latent health status. The findings confirm the presence of adverse selection hypothesis in personally purchased health insurance and moral hazard in all health insurance categories.

LINPING, X., LULU, Z., WEIDONG, T. & HONG, L. *Evaluating sustainability of medical insurance scheme for urban employed individuals in China.* 600–625. In the late 1990s, the Chinese government established the medical insurance scheme for urban employees and retirees. Given China's considerable size and diversity, the reform of the medical care system faces many challenges. It is important to analyse and evaluate the impact of the reform on individuals'



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health care benefits and on their financial burden due to medical expenses. This research investigates the sustainability of the urban medical insurance system. With co-operation from the Bureau of Labour and Social Security of Kunming of China, this article creates a static micro-simulation model for predicting and evaluating the medical insurance policies. The model investigates the balances of the social pool fund and personal savings accounts. In the model, administrative data over 2001–2005 were used as te micro-simulation base data sets. With 2006 as the commencement year, the model forecasts medical service expenses and medical insurance policy settings for five years until 2010. This research aims to advance the understanding and impact of health insurance reform in China, and to assist in future policy formulation and implementation.

ROBERTS, J., RICE, N. & JONES, A. M. *Early retirement among men in Britain and Germany: how important is health?* 644–667. Britain and Germany, like much of the Western world, have concerns about the ageing of the population and early exit of older workers from the labour market. Policy debates have focused on direct changes to retirement ages and incentives to encourage greater pension saving. Less attention has been paid to the role of health. We use hazard models applied to longitudinal data from Britain and Germany to estimate the effect of health on early retirement among men. Our results show that health is a key determinant, and its effect is large compared to that of other variables, including the type of pension an individual has access to.

SHANG, B. & GOLDMAN, D. *Prescription drug coverage and Medicare spending among U.S. elderly.* 539–567. The introduction of Medicare Part D has generated interest in the cost of providing drug coverage to the elderly. Of paramount importance - often unaccounted for in budget estimates - are the salutary effects that increased prescription drug use might have on other Medicare spending. This paper uses longitudinal data from the Medicare Current Beneficiary survey to estimate how prescription drug benefits affect Medicare spending. We compare spending and service use for Medigap enrollees with and without drug coverage. Owing to concerns about selection, we use variation in supply-side regulations of the individual insurance market - including guaranteed issue and community rating - as instruments for prescription drug coverage. We employ a discrete factor model to control for individual-level heterogeneity that might induce bias in the effects of drug coverage. We find Medigap prescription drug coverage significantly increases drug spending and reduces Medicare part A spending. Medigap prescription drug coverage reduces Medicare Part B spending, but the estimates are not statistically significant. Furthermore, the substitution effect decreases as income rises, and thus provides support for the low-income assistance program of Medicare Part D.

VAN KLEEF, R. C., BECK, K. & BUCHNER, F. *Risk-type concentration and efficiency incentives: a challenge for the risk adjustment formula*. 503–520. An important goal of risk-adjusted capitation payments (RACPs) to competitive community-rated health plans - that may differ in coverage and/or the organisation of delivering care - is to reduce incentives for risk selection while maintaining incentives for efficiency. In most schemes, RACPs are simply based on the average observed costs in risk groups (in a prior year). We show that under this procedure, incentives for efficiency will not always be maintained: when identical risk types are concentrated in the same health plans - due to selection, specialisation or just coincidence - cost savings can be captured by the RACPs and leak away from these plans.

ZUCHANDKE, A., REDDEMAN, S., KRUMMAKER, S. & VON DER SCHULENBURG, J. MATTIAS GRAF. *Impact of the introduction of the social long-term care insurance in Germany*



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*on financial security assessment in case of long-term care need*. 626–643. The discussion concerning long-term care insurance in Germany barely exceeds the financial state of the social system. The view of the insured involved is largely ignored. This paper analyses the effect of the introduction of compulsory long-term care insurance in 1995 in Germany on the perception of financial security when needing long-term care. Using different regression techniques on a subset of the German Socio-Economic Panel (SOEP) data, we show that the introduction led to a general positive shift of the assessment. Furthermore, experience with long-term care had no significant effect before the introduction but a positive effect afterwards. Also, the perception of financial security is found to be increasing with income at both times with similar magnitudes.

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BALUCH, F., MUTENGA, S. & PARSONS, C. *Insurance, systemic risk and the financial crisis*. 126–163. In this paper we assess the impact of the financial crisis on insurance markets and the role of the insurance industry in the crisis itself. We examine some previous "insurance crises" and consider the effect of the crisis on insurance risk—the liabilities arising from contracts that insurers underwrite. We then analyse the effects of the crisis on the performance of insurers in different markets and assess the extent of systemic risk in insurance. We conclude that, while systemic risk remains lower in insurance than in the banking sector, it is not negligible and has grown in recent years, partly as a consequence of insurers' increasing links with banks and their recent focus on non-(traditional) insurance activities, including structured finance. We conclude by considering the structural changes in the insurance industry that are likely to result from the crisis, including possible effects on "bancassurance" activity, and offer some thoughts on changes in the regulation of insurance markets that might ensue.

CHANG, P-R., PENG, J-L. & FAN, C. K. *A comparison of Bancassurance and traditional insurer sales channels*. 76–93. Although various sales channels exist for insurance products, no existing research compares their sales efficiency. This study offers a comparison of bancassurance and traditional sales channels in Taiwan. Using a data envelopment analysis approach, this study first computes the efficiencies of bancassurance and traditional sales channels separately. The efficiency score of the traditional sales channel is significantly higher than that of a comparable bancassurance channel. Furthermore, the efficiency relationship between the bancassurance and the traditional sales channels is independent. These findings have significant implications for the insurance industry and ongoing research in this field.

DIERS, D. *Management strategies in multi-year enterprise risk management*. 107–125. In enterprise risk management, strategies should be evaluated and managed from a multi-year view. In this paper, we present a multi-year model approach and apply a multi-year risk-capital concept to enable the company's "Own Risk and Solvency Assessment" as a part of enterprise risk management on a multi-year basis. We show under which assumptions an allocation method gives the "right" strategic incentives. We illustrate the usefulness of the concept for managerial decision support using data from a German non-life insurer.

GATZERT, N., HUBER, C. & SCHMEISER, H. *On the valuation of investment guarantees in unit-linked life insurance: a customer perspective*. 3–29. Interest rate guarantees in unit-linked life



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insurance products ensure that at contract maturity, at least a minimum guaranteed amount is paid, even if the mutual fund falls below the guaranteed level. Strongly depending on the riskiness of the underlying mutual fund, these guarantees can be of substantial value. However, while insurer pricing is based on the replication of cash flows, customers are more likely to base their decisions on individual preferences. The aim of this paper is to contrast reservation prices for guarantees in unit-linked life insurance policies based on customers' subjective willingness to pay with a financial pricing approach, an investigation that has not been undertaken to date. To do so, we use an online questionnaire survey and calculate reservation prices using option pricing theory. Our findings reveal that even though the majority of the participants in the online questionnaire are employed in the field of insurance, subjective prices are difficult to derive and are significantly lower on average than the prices obtained using a financial pricing model. However, a considerable portion of participants is still willing to pay a substantially higher price.

KLUMPES, P. J. M. & SCHUERMANN, S. *Corporate, product and distribution strategies in the European life insurance industry.* 50–75. This paper examines corporate, marketing and product distribution strategies in the cost and revenue efficiency across a sample of life insurers that operate in European markets with the highest insurance concentration and density. We predict that these strategies are also affected by segmentation and cross-country differences in regulatory type ("alpine" vs. "atlantic"), which facilitate managerial opportunistic behaviour in choice of distribution strategy. This contrasts with the standard market efficiency hypothesis, which predicts that firms that adopt one of three generic strategies (cost, customer focus and product differentiation) are more efficient than rivals that fail to adopt one of these strategies. Our results support the prediction of the market imperfection hypothesis that firms with non-exclusive distribution systems are less costly and profit-efficient. We also find that firms surviving the recent financial crisis rely on exclusive distribution channels, product differentiation and experience the highest degree of change in cost efficiency over time of increasing deregulation. These findings imply that imperfections in these markets are driven by a combination of tax incentives, regulatory arbitrage and technology transfer of larger firms that exploit their size and dominance to use multiple distribution systems, which are more costly and profit-efficient.

NJEGOMIR, V. & STOJIC, D. *Liberalisation and market concentration impact on performance of the non-life insurance industry: the evidence from Eastern Europe.* 94–106. The aim of this paper is to examine market structure, conduct and performance relationship (S-C-P) hypothesis for the non-life insurance industry in Eastern European countries. Additionally, we examine the effect of liberalisation on market structure and performance. We use the country-specific fixed effects models for panel data for the period 2004–2008 allowing each cross-sectional unit to have a different intercept term serving as an unobserved random variable that is potentially correlated with the observed regressors. Three models are presented, each placing market structure, liberalisation and profitability in a distinct environment defined by related control variables. The research results support the S-C-P hypothesis in all of the observed models, showing evidence of strong influence of market structure and liberalisation on market profitability. These results could be useful in decision-making for both governments and insurance companies.

VAN BRAGT, D. & KORT, D-J. *Liability-driven investing for life insurers.* 30–49. Liability-driven investing (LDI) has recently emerged as a powerful paradigm in financial risk management. The basic idea behind LDI is to split the company's balance sheet into two separate balance sheets: one for the liabilities and the matching assets and one for the other (return) assets and the surplus. We show that constructing a proper liability-hedging portfolio (LHP) is very attractive for life



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insurers because the liability-driven risks can be suppressed without a negative impact on overall return. When these risks are covered by the LHP, the return assets can be optimised using well-known (Markowitz) optimisation techniques or (equity) hedge strategies. The LDI approach thus stimulates insurers to address all risks embedded in the insurance liabilities and facilitates the subsequent optimisation of the return assets.

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BERTONI, F. & CROCE, A. *The productivity of European life insurers: best-practice adoption vs. innovation*. 165–185. The aim of this work is to investigate the drivers of productivity evolution in the European life insurance industry in the aftermath of the enforcement of the Third Directive. We apply Data Envelopment Analysis (DEA) to a panel of 602 life insurance companies operating in five European countries (Germany, France, Italy, Spain and the U.K.) between 1997 and 2004 and develop a generalized Malmquist efficiency decomposition to gauge the relative importance of two sources of productivity change: the improvement of best-practices via innovation, and the adoption of practices currently adopted by local or foreign best-in-class insurers. We find that productivity increased on an annual basis by 6.71 per cent; the increase has been mostly due to innovation in best-practices (6.67 per cent), while best-practice adoption contributed by a mere 0.04 per cent. Our findings also indicate that, over the period of our analysis, innovation of best-practices was attributable to technological change. We find no evidence, instead, that productivity has been driven by a shift in the risk profile of insurers.

BRAUN, A., RYMASZEWSKI, P. & SCHMEISER, H. *A traffic light approach to solvency measurement of Swiss occupational pension funds*. 254–282. In this paper, we combine a stochastic pension fund model with a traffic light approach to solvency measurement of occupational pension funds in Switzerland. Assuming normally distributed asset returns, a closed-form solution can be derived. Despite its simplicity, we believe the model comprises the essential risk sources needed in supervisory practice. Owing to its ease of calibration, it is well suited for a regulatory application in the fragmented Swiss market, keeping costs of solvency testing at a minimum. We calibrate and implement the model for a small sample of ten Swiss pension funds in order to illustrate its application and the derivation of traffic light signals. In addition, a sensitivity analysis is conducted to identify important drivers of the shortfall probabilities for the traffic light conditions. Although our analysis concentrates solely on Switzerland, the approach could also be applied to similar pension systems.

CHUNG-FERN, R. & WEN-HSIN, H. *Value relevance of embedded value and IFRS 4 insurance contracts*. 283–303. Copy from http://www.palgrave-journals.com/gpp/index.html.

FLOREANI, A. *Risk margin estimation through the cost of capital approach: some conceptual issues*. 226–253. The Solvency II directive requires that insurance liabilities are valued using a best estimate plus a risk margin. The risk margin should be estimated using the cost of capital approach, that is the cost of the solvency capital requirement—which is computed through a value at risk measure—needed to support the insurance obligation until settlement. The unitary cost of capital applied to the future capital requirement should be fixed. This paper deals with conceptual issues relating to the risk margin estimate through the cost of capital approach.



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It shows that the Solvency II specification of the methodology is consistent with financial economics. However, the theoretical framework required (a frictionless and normally distributed world) is too far-fetched to be acceptable. Even if these conditions were satisfied, a variable unitary cost of capital must be used.

XIE, X., LU, W., REISING, J. & STOHS, M. H. *Demutualisation, control and efficiency in the U.S. life insurance industry.* 197–225. This paper examines the role of corporate governance in the demutualisation wave in the U.S. life insurance industry during the 1990s and 2000s. The efficiency hypothesis suggests a firm should experience improved performance after demutualisation and managers should only gain from superior performance. Alternately, the managerial welfare hypothesis proposes that executives gain independence of company performance. This research suggests that demutualisation is value-enhancing for firms converting through initial public offerings (IPOs), but value-neutral for firms that convert but stay private. Firms converting into public companies experience increased CEO turnover that leads to efficiency improvement. CEOs of these firms receive higher compensation after demutualisation, but most of the gain is due to a jump in incentive compensation. Firms converting but staying private do not have a similar significant increase in CEO compensation. Overall, our results provide evidence that value-enhancement, not private managerial welfare, motivates demutualisation.

YUH, Y. *Assessing adequacy of retirement income for U.S. households: a replacement ratio approach.* 304–323. The retirement income replacement ratio is projected using the Federal Reserve's Survey of Consumer Finances. On the basis of lognormal portfolio projections and current portfolio allocation, at least 44 per cent of pre-retired households will not be able to maintain 70 per cent of permanent income standard in retirement. Households planning to retire later and taking a high financial risk in savings and investments have a higher projected replacement ratio. Households having a high proportion of non-housing assets held in equity or bonds have a higher projected replacement ratio than those having a high proportion in cash equivalents.

YUNG-MING, S. *What motivates insurers to use derivatives: evidence from the United Kingdom life insurance industry.* 186–196. Using firm-specific variables that proxy for the motivations of life insurers' decision to participate in derivative transactions, we examine existing theories of corporate hedging behaviour. Our findings support the evidence of previous research that risk management and scale factors explain the use of derivatives. We observe a substitution effect that insurers use on-balance-sheet hedging through structuring their assets and liabilities to reduce price risks.

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## Geneva Risk and Insurance Review

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CHIU, W. H. *Skewness preference, risk taking and expected utility maximisation.* 108–129. Available empirical evidence suggests that skewness preference plays an important role in



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understanding asset pricing and gambling. This paper establishes a skewness-comparability condition on probability distributions that is necessary and sufficient for any decision-maker's preferences over the distributions to depend on their means, variances, and third moments only. Under the condition, an Expected Utility maximizer's preferences for a larger mean, a smaller variance, and a larger third moment are shown to parallel, respectively, his preferences for a first-degree stochastic dominant improvement, a mean-preserving contraction, and a downside risk decrease and are characterized in terms of the von Neumann-Morgenstern utility function in exactly the same way. By showing that all Bernoulli distributions are mutually skewness comparable, we further show that in the wide range of economic models where these distributions are used individuals' decisions under risk can be understood as trade-offs between mean, variance, and skewness. Our results on skewness-inducing transformations of random variables can also be applied to analyze the effects of progressive tax reforms on the incentive to make risky investments.

HUANG, R. J., LIU, Y-J. & TZENG, L. Y. *Hidden overconfidence and advantageous selection.* 93–107. Theories of adverse selection and moral hazard predict the occurrence of the risk and the coverage of the insurance should be positively correlated, whereas empirical researches find little support of it. This paper provides a theoretical model of hidden overconfidence and demonstrates that a competitive insurance market may settle on separating equilibrium with advantageous selection predicting a negative relationship between risk and coverage. By assuming heterogeneity in risk perception and hidden action on self-protection, we find that, in equilibrium, the rational type of individual takes precautions to reduce the loss probability, whereas the overconfident type of individual will not make any effort. In the separating equilibrium, the insurer provides a product with high coverage to attract rational type of individual (low risk), and a product with low coverage for overconfident type of individual (high risk). In addition, other types of equilibrium such as adverse selection or linear premium rate are also found.

KRYGER, E. M. *Pension fund design under long-term fairness constraints*. 130–159. We consider optimal portfolio insurance for a mutually owned with-profits pension fund. First, intergenerational fairness is imposed by requiring that the pension fund is driven towards a steady state. Subject to this condition the optimal asset allocation is identified among the class of constant proportion portfolio insurance strategies by maximising expected power utility of the benefit. For a simple contract approximate analytical results are available and accurate, whereas for a more involved contract Monte Carlo methods must be applied to pick out the best design. The main insights are (i) aggressive investment strategies are disastrous for the clients; (ii) in most cases it is optimal to gear the bonus reserve; and (iii) the results are far less sensitive to the agent's risk aversion than in the classical case of Merton (1969), and as opposed to Merton horizon matters even with constant investment opportunities (because of the serial dependence between bonuses).

LEE, K. *Wealth effects on self-insurance*. 160–171. This paper considers the wealth effects on self-insurance investment that reduces loss. Wealthier individuals can bear the risk better, and invest less in self-insurance with two states of the world. Self-insurance, like insurance, is thus an inferior good. This known result does not extend to many states. The reason is that an increase in self-insurance does not necessarily reduce final wealth in good states and increase it in bad states. Self-insurance thus may not act as insurance, and wealthier individuals may not necessarily invest less in self-insurance. The paper proposes a condition under which self-insurance is inferior, and a condition under which it is normal.



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36(1), 2011

CHEN, L-R., LAI, G. C. & WANG, J. L. *Conversion and efficiency performance changes: evidence from the U.S. property-liability insurance industry.* 1–35. This study investigates whether the conversion of U.S. property-liability insurers improves their efficiency performance before and after the conversion. We estimate relative efficiency of converting insurers and control insurers using data envelopment analysis. The Malmquist analysis is also used to measure changes in efficiency pre- and post-conversion. The evidence shows that converting insurers experience larger gains in cost efficiency and total productivity change than mutual control insurers before conversion. In addition, the empirical results indicate that converting insurers improve efficiency after conversion. These results are robust with respect to both the value-added and the financial intermediary approaches. The overall results support the efficiency hypothesis proposed by Mayers and Smith (1986).

QUITTARD-PINON, F. & RANDRIANARIVONY, R. *Impacts of jumps and stochastic interest rates on the fair costs of guaranteed minimum death benefit contracts.* 51–73. The authors offer a new perspective to the field of guaranteed minimum death benefit contracts, especially for simple return premium and rising floor guarantees. A particular feature of these contracts is a guaranteed capital upon the insured's death. A complete methodology based on the generalized Fourier transform is proposed to investigate the impacts of jumps and stochastic interest rates. This paper thus extends Milevsky and Posner (2001). If jumps alone are considered, similar results are obtained, but, when stochastic interest rates are introduced, the fair costs of the guarantee feature are found to be substantially higher in this more general economy.

WAMBACH, A. & ENGEL, A. R. *Surety bonds with fair and unfair pricing.* 36–50. Surety bonds are instruments used in public and private procurement to avoid the problem of contractor bankruptcy. A surety company issuing such a bond guarantees to either finish the project itself or pay the bond to the procurement agency in case of contractor's bankruptcy. This situation is analysed under the assumption that the bond is either priced fairly, or a risk loading that is proportional to the money at risk is imposed. If the surety is priced fairly, full insurance (or even overinsurance) is optimal. If the surety is priced unfairly, more solvent contractors are more likely to win, thus the problem of abnormally low tenders is alleviated.

YANG, C. C., LI, L. S. & WEN, M-M. *Weather risk hedging in the European markets and international investment diversification.* 74–94. This article analyses weather risk hedging efficiency in three European countries using weather derivatives traded at Chicago Mercantile Exchange (CME) and explores the potential of weather derivatives as a new investment asset to further diversify investors' portfolios. The results document that the CME European weather contracts are generally effective in hedging the temperature risk in the three European countries. However, for a specific country, weather risk hedging using other countries' weather indexes is generally not effective. Zero or little correlation among international weather indexes and stock market indexes indicates that weather derivatives should be an efficient investment diversifier. This research provides important insights to both weather risk hedgers and investors.

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## Insurance: Mathematics & Economics

48(1), 2011

LUO, S. & TAKSAR, M. *On absolute ruin minimization under a diffusion approximation model.* 123–133. In this paper, we assume that the surplus process of an insurance entity is represented by a pure diffusion. The company can invest its surplus into a Black–Scholes risky asset and a risk free asset. We impose investment restrictions that only a limited amount is allowed in the risky asset and that no short-selling is allowed. We further assume that when the surplus level becomes negative, the company can borrow to continue financing. The ultimate objective is to seek an optimal investment strategy that minimizes the probability of absolute ruin, i.e. the probability that the liminf of the surplus process is negative infinity. The corresponding Hamilton–Jacobi–Bellman (HJB) equation is analyzed and a verification theorem is proved; applying the HJB method we obtain explicit expressions for the S-shaped minimal absolute ruin function and its associated optimal investment strategy. In the second part of the paper, we study the optimization problem with both investment and proportional reinsurance control. There the minimal absolute ruin function and the feedback optimal investment–reinsurance control are found explicitly as well.

BUCH-KROMANN, T., GUILLEN, M., LINTON, O. & NIELSEN, J. P. *Multivariate density estimation using dimension reducing information and tail flattening transformations.* 99–110. We propose a nonparametric multiplicative bias corrected transformation estimator designed for heavy tailed data. The multiplicative correction is based on prior knowledge and has a dimension reducing effect at the same time as the original dimension of the estimation problem is retained. Adding a tail flattening transformation improves the estimation significantly–particularly in the tail–and provides significant graphical advantages by allowing the density estimation to be visualized in a simple way. The combined method is demonstrated on a fire insurance data set and in a data-driven simulation study.

CHERUBINI, U., MULINACCI, S. & ROMAGNOLI, S. *On the distribution of the (un)bounded sum of random variables.* 56–63. We propose a general treatment of random variables aggregation accounting for the dependence among variables and bounded or unbounded support of their sum. The approach is based on the extension to the concept of convolution to dependent variables, involving copula functions. We show that some classes of copula functions (such as Marshall–Olkin and elliptical) cannot be used to represent the dependence structure of two variables whose sum is bounded, while Archimedean copulas can be applied only if the generator becomes linear beyond some point. As for the application, we study the problem of capital allocation between risks when the sum of losses is bounded.

COSSETTE, H., MARCEAU, É. & TOUREILLE, F. *Risk models based on time series for count random variables.* 19–28. In this paper, we generalize the classical discrete time risk model by introducing a dependence relationship in time between the claim frequencies. The models used are the Poisson autoregressive model and the Poisson moving average model. In particular, the aggregate claim amount and related quantities such as the stop-loss premium, value at risk and tail value at risk are discussed within this framework.



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DORNHEIM, H. & BRAZAUSKAS, V. *Robust–efficient credibility models with heavy-tailed claims: A mixed linear models perspective*. 72–84. In actuarial practice, regression models serve as a popular statistical tool for analyzing insurance data and tariff ratemaking. In this paper, we consider classical credibility models that can be embedded within the framework of mixed linear models. For inference about fixed effects and variance components, likelihood-based methods such as (restricted) maximum likelihood estimators are commonly pursued. However, it is well-known that these standard and fully efficient estimators are extremely sensitive to small deviations from hypothesized normality of random components as well as to the occurrence of outliers. To obtain better estimators for premium calculation and prediction of future claims, various robust methods have been successfully adapted to credibility theory in the actuarial literature. The objective of this work is to develop robust and efficient methods for credibility when heavy-tailed claims are approximately log-location–scale distributed. To accomplish that, we first show how to express additive credibility models such as Bühlmann–Straub and Hachemeister ones as mixed linear models with symmetric or asymmetric errors. Then, we adjust adaptively truncated likelihood methods and compute highly robust credibility estimates for the ordinary but heavy-tailed claims part. Finally, we treat the identified excess claims separately and find robust–efficient credibility premiums. Practical performance of this approach is examined–via simulations–under several contaminating scenarios. A widely studied real-data set from workers' compensation insurance is used to illustrate functional capabilities of the new robust credibility estimators.

EICHNER, T. *Portfolio selection and duality under mean variance preferences*. 146–152. This paper uses duality to analyze an investor's behavior in a n-asset portfolio selection problem when the investor has mean variance preferences. The indirect utility and wealth requirement functions are used to derive Roy's identity, Shephard's lemma and the Slutsky equation. In our simple Slutsky equation the income effect is characterized by decreasing absolute risk aversion (DARA) and the substitution effect is always positive [negative] with respect to an asset's holding if the asset's mean return [risk] increases. Substitution effect and income effect work in the same direction presupposed mean variance preferences display DARA.

HABERMAN, S. & RENSHAW, A. *A comparative study of parametric mortality projection models*. 35–55. The relative merits of different parametric models for making life expectancy and annuity value predictions at both pensioner and adult ages are investigated. This study builds on current published research and considers recent model enhancements and the extent to which these enhancements address the deficiencies that have been identified of some of the models. The England & Wales male mortality experience is used to conduct detailed comparisons at pensioner ages, having first established a common basis for comparison across all models. The model comparison is then extended to include the England & Wales female experience and both the male and female USA mortality experiences over a wider age range, encompassing also the working ages.

KONSTANTINIDES, D. G. & KOUNTZAKIS, C. E. *Risk measures in ordered normed linear spaces with non-empty cone-interior.* 111–122. In this paper, we use tools from the theory of partially ordered normed linear spaces, especially the bases of cones. This work extends the well-known results for convex and coherent risk measures. Its linchpin consists in the replacement of the riskless bond by some interior point in the cone of the space of risks, which stands as the alternative numeraire.



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MACCI, C., & TORRISI, G. L. *Risk processes with shot noise Cox claim number process and reserve dependent premium rate*. 134–145. We consider a suitable scaling, called the slow Markov walk limit, for a risk process with shot noise Cox claim number process and reserve dependent premium rate. We provide large deviation estimates for the ruin probability. Furthermore, we find an asymptotically efficient law for the simulation of the ruin probability using importance sampling. Finally, we present asymptotic bounds for ruin probabilities in the Bayesian setting.

MACDONALD, B-J. & CAIRNS, A. J. G. *Three retirement decision models for defined contribution pension plan members: A simulation study.* 1–18. This paper examines the hypothetical retirement behavior of defined contribution (DC) pension plan participants. Using a Monte Carlo simulation approach, we compare and discuss three retirement decision models: the two-thirds replacement ratio benchmark model, the option-value of continued work model and a newly-developed "one-year" retirement decision model. Unlike defined benefit (DB) pension plans where economic incentives create spikes in retirement at particular ages, all three retirement decision models suggest that the retirement ages of DC participants are much more smoothly distributed over a wide range of ages. We find that the one-year model possesses several advantages over the other two models when representing the theoretical retirement choice of a DC pension plan participant. First, its underlying theory for retirement decision-making is more feasible given the distinct features and pension drivers of a DC plan. Second, its specifications produce a more logical relationship between an individual's decision to retire and his/her age and accumulated retirement wealth. Lastly, although the one-year model is less complex than the option-value model as the DC participants' scope is only one year, the retirement decision is optimal over all future projected years if projections are made using reasonable financial assumptions.

MANNER, H. & SEGERS, J. *Tails of correlation mixtures of elliptical copulas*. 153–160. Correlation mixtures of elliptical copulas arise when the correlation parameter is driven itself by a latent random process. For such copulas, both penultimate and asymptotic tail dependence are much larger than for ordinary elliptical copulas with the same unconditional correlation. Furthermore, for Gaussian and Student t-copulas, tail dependence at sub-asymptotic levels is generally larger than in the limit, which can have serious consequences for estimation and evaluation of extreme risk. Finally, although correlation mixtures of Gaussian copulas inherit the property of asymptotic independence, at the same time they fall in the newly defined category of near asymptotic dependence. The consequences of these findings for modeling are assessed by means of a simulation study and a case study involving financial time series.

ROORDA, B. & SCHUMACHER, J. M. *The strictest common relaxation of a family of risk measures*. 29–34. Operations which form new risk measures from a collection of given (often simpler) risk measures have been used extensively in the literature. Examples include convex combination, convolution, and the worst-case operator. Here we study the risk measure that is constructed from a family of given risk measures by the best-case operator; that is, the newly constructed risk measure is defined as the one that is as restrictive as possible under the condition that it accepts all positions that are accepted under any of the risk measures from the family. In fact we define this operation for conditional risk measures, to allow a multiperiod setting. We show that the well-known VaR risk measure can be constructed from a family of conditional expectations by a combination that involves both worst-case and best-case operations. We provide an explicit description of the acceptance set of the conditional risk measure that is obtained as the strictest common relaxation of two given conditional risk measures.



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TAKSAR, M. & ZENG, X. *Optimal non-proportional reinsurance control and stochastic differential games.* 64–71. We study stochastic differential games between two insurance companies who employ reinsurance to reduce risk exposure. We consider competition between two companies and construct a single payoff function of two companies' surplus processes. One company chooses a dynamic reinsurance strategy in order to maximize the payoff function while its opponent is simultaneously choosing a dynamic reinsurance strategy so as to minimize the same quantity. We describe the Nash equilibrium of the game and prove a verification theorem for a general payoff function. For the payoff function being the probability that the difference between two surplus reaches an upper bound before it reaches a lower bound, the game is solved explicitly.

VERDONCK, T. & DEBRUYNE, M. *The influence of individual claims on the chain-ladder estimates: Analysis and diagnostic tool.* 85–98. The chain-ladder method is a widely used technique to forecast the reserves that have to be kept regarding claims that are known to exist, but for which the actual size is unknown at the time the reserves have to be set. In practice it can be easily seen that even one outlier can lead to a huge over- or underestimation of the overall reserve when using the chain-ladder method. This indicates that individual claims can be very influential when determining the chain-ladder estimates. In this paper the effect of contamination is mathematically analyzed by calculating influence functions in the generalized linear model framework corresponding to the chain-ladder method. It is proven that the influence functions are unbounded, confirming the sensitivity of the chain-ladder method to outliers. A robust alternative is introduced to estimate the generalized linear model parameters in a more outlier resistant way. Finally, based on the influence functions and the robust estimators, a diagnostic tool is presented highlighting the influence of every individual claim on the classical chain-ladder estimates. With this tool it is possible to detect immediately which claims have an abnormally positive or negative influence on the reserve estimates. Further examination of these influential points is then advisable. A study of artificial and real run-off triangles shows the good performance of the robust chain-ladder method and the diagnostic tool.

## Insurance: Mathematics & Economics

### 48(2), 2011

ALBRECHER, H., CONSTANTINESCU, C. & LOISEL, S. *Explicit ruin formulas for models with dependence among risks.* 265–270. We show that a simple mixing idea allows one to establish a number of explicit formulas for ruin probabilities and related quantities in collective risk models with dependence among claim sizes and among claim inter-occurrence times. Examples include compound Poisson risk models with completely monotone marginal claim size distributions that are dependent according to Archimedean survival copulas as well as renewal risk models with dependent inter-occurrence times.

BEE, M. *Adaptive Importance Sampling for simulating copula-based distributions.* 237–245. In this paper, we propose a generalization of importance sampling, called Adaptive Importance Sampling, to approximate simulation of copula-based distributions. Unlike existing methods for copula simulation that have appeared in the literature, this algorithm is broad enough to be used for any absolutely continuous copula. We provide details of the algorithm including rules for stopping the iterative process and consequently assess its performance using extensive Monte Carlo experiments. To assist in its extension to several dimensions, we discuss procedures for



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identifying the crucial parameters in order to achieve desirable results especially as the size of the dimension increases. Finally, for practical illustration, we demonstrate the use of the algorithm to price First-to-Default credit swap, an important credit derivative instrument in the financial market. The method works exquisitely well even for large dimensions making it a valuable tool for simulating from many different classes of copulas including those which have been difficult to sample from using traditional techniques.

BERMUDEZ, L. & KARLIS, D. *Bayesian multivariate Poisson models for insurance ratemaking*. 226–236. When actuaries face the problem of pricing an insurance contract that contains different types of coverage, such as a motor insurance or a homeowner's insurance policy, they usually assume that types of claim are independent. However, this assumption may not be realistic: several studies have shown that there is a positive correlation between types of claim. Here we introduce different multivariate Poisson regression models in order to relax the independence assumption, including zero-inflated models to account for excess of zeros and overdispersion. These models have been largely ignored to date, mainly because of their computational difficulties. Bayesian inference based on MCMC helps to resolve this problem (and also allows us to derive, for several quantities of interest, posterior summaries to account for uncertainty). Finally, these models are applied to an automobile insurance claims database with three different types of claim. We analyse the consequences for pure and loaded premiums when the independence assumption is relaxed by using different multivariate Poisson regression models together with their zero-inflated versions.

CHOE, G. H. & JANG, H. J. *Efficient algorithms for basket default swap pricing with multivariate Archimedean copulas*. 205–213. We introduce a new importance sampling method for pricing basket default swaps employing exchangeable Archimedean copulas and nested Gumbel copulas. We establish more realistic dependence structures than existing copula models for credit risks in the underlying portfolio, and propose an appropriate density for importance sampling by analyzing multivariate Archimedean copulas. To justify efficiency and accuracy of the proposed algorithms, we present numerical examples and compare them with the crude Monte Carlo simulation, and finally show that our proposed estimators produce considerably smaller variances.

DRIESSEN, THEO S. H.; VITO, FRAGNELLI; KATSEV, ILYA V.; KHMELNITSKAYA, ANNA B. *On 1-convexity and nucleolus of co-insurance games*. 217–225. The insurance situation in which an enormous risk is insured by a number of insurance companies is modeled through a cooperative TU game, the so-called co-insurance game, first introduced in Fragnelli and Marina (2004). In this paper we present certain conditions on the parameters of the model that guarantee the 1-convexity property of co-insurance games which in turn ensures the nonemptiness of the core and the linearity of the nucleolus as a function of the variable premium. Further we reveal conditions when a co-insurance game is representable in the form of a veto-removed game and present an efficient final algorithm for computing the nucleolus of a veto-removed game.

FENG, R. *An operator-based approach to the analysis of ruin-related quantities in jump diffusion risk models*. 304–313. Recent developments in ruin theory have seen the growing popularity of jump diffusion processes in modeling an insurer's assets and liabilities. Despite the variations of technique, the analysis of ruin-related quantities mostly relies on solutions to certain differential equations. In this paper, we propose in the context of Lévy-type jump diffusion risk models a solution method to a general class of ruin-related quantities. Then we present a



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novel operator-based approach to solving a particular type of integro-differential equations. Explicit expressions for resolvent densities for jump diffusion processes killed on exit below zero are obtained as by-products of this work.

HABERMAN, S., KHALAF-ALLAH, M. & VERRALL, R. *Entropy, longevity and the cost of annuities*. 197–204. This paper presents an extension of the application of the concept of entropy to annuity costs. Keyfitz (1985) introduced the concept of entropy, and analysed this in the context of continuous changes in life expectancy. He showed that a higher level of entropy indicates that the life expectancy has a greater propensity to respond to a change in the force of mortality than a lower level of entropy. In other words, a high level of entropy means that further reductions in mortality rates would have an impact on measures like life expectancy. In this paper, we apply this to the cost of annuities and show how it allows the sensitivity of the cost of a life annuity contract to changes in longevity to be summarized in a single figure index.

KLUSIK, P. & PALMOWSKI, Z. *Quantile hedging for equity-linked contracts*. 280–286. We consider an equity-linked contract whose payoff depends on the lifetime of the policy holder and the stock price. We provide the best strategy for an insurance company assuming limited capital for the hedging. The main idea of the proof consists in reducing the construction of such strategies for a given claim to a problem of superhedging for a modified claim, which is the solution to a static optimization problem of the Neyman–Pearson type. This modified claim is given via some sets constructed in an iterative way. Some numerical examples are also given.

KWAK, M., SHIN, Y. H. & CHOI, U. J. *Optimal investment and consumption decision of a family with life insurance*. 176–188. We study an optimal portfolio and consumption choice problem of a family that combines life insurance for parents who receive deterministic labor income until the fixed time T. We consider utility functions of parents and children separately and assume that parents have an uncertain lifetime. If parents die before time T, children have no labor income and they choose the optimal consumption and portfolio with remaining wealth and life insurance benefit. The object of the family is to maximize the weighted average of utility of parents and that of children. We obtain analytic solutions for the value function and the optimal policies, and then analyze how the changes of the weight of the parents' utility function and other factors affect the optimal policies.

LIU, X., JANG, J. & KIM, S. M. *An application of comonotonicity theory in a stochastic life annuity framework*. 271–279. A life annuity contract is an insurance instrument which pays pre-scheduled living benefits conditional on the survival of the annuitant. In order to manage the risk borne by annuity providers, one needs to take into account all sources of uncertainty that affect the value of future obligations under the contract. In this paper, we define the concept of annuity rate as the conditional expected present value random variable of future payments of the annuity, given the future dynamics of its risk factors. The annuity rate deals with the non-diversifiable systematic risk contained in the life annuity contract, and it involves mortality risk as well as investment risk. While it is plausible to assume that there is no correlation between the two risks, each affects the annuity rate through a combination of dependent random variables. In order to understand the probabilistic profile of the annuity rate, we apply comonotonicity theory to approximate its quantile function. We also derive accurate upper and lower bounds for prediction intervals for annuity rates. We use the Lee–Carter model for mortality risk and the Vasicek model for the term structure of interest rates with an annually renewable fixed-income investment policy. Different investment strategies can be handled using this framework.



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MAO, T. & HU, T. *A new proof of Cheung's characterization of comonotonicity.* 214–216. It is well known that if a random vector with given marginal distributions is comonotonic, it has the largest sum in the sense of the convex order. Cheung (2008) proved that the converse of this assertion is also true, provided that all marginal distribution functions are continuous and that the underlying probability space is atomless. This continuity assumption on the marginals was removed by Cheung (2010). In this short note, we give a new and simple proof of Cheung's result without the assumption that the underlying probability space is atomless.

NTEUKAM, T. O., PLANCHET, F. & THEROND, P. *Optimal strategies for hedging portfolios of unit-linked life insurance contracts with minimum death guarantee.* 161–175. In this paper, we are interested in hedging strategies which allow the insurer to reduce the risk to their portfolio of unit-linked life insurance contracts with minimum death guarantee. Hedging strategies are developed in the Black and Scholes model and in the Merton jump–diffusion model. According to the new frameworks (IFRS, Solvency II and MCEV), risk premium is integrated into our valuations. We will study the optimality of hedging strategies by comparing risk indicators (Expected loss, volatility, VaR and CTE) in relation to transaction costs and costs generated by the re-hedging error. We will analyze the robustness of hedging strategies by stress-testing the effect of a sharp rise in future mortality rates and a severe depreciation in the price of the underlying asset.

PETERS, G. W., BYRNES, A. D. & SHEVCHENKO, P. V. *Impact of insurance for operational risk: Is it worthwhile to insure or be insured for severe losses?* 287–303. Under the Basel II standards, the Operational Risk (OpRisk) advanced measurement approach allows a provision for reduction of capital as a result of insurance mitigation of up to 20%. This paper studies different insurance policies in the context of capital reduction for a range of extreme loss models and insurance policy scenarios in a multi-period, multiple risk setting. A Loss Distributional Approach (LDA) for modeling of the annual loss process, involving homogeneous compound Poisson processes for the annual losses, with heavy-tailed severity models comprised of a-stable severities is considered. There has been little analysis of such models to date and it is believed insurance models will play more of a role in OpRisk mitigation and capital reduction in future. The first question of interest is when would it be equitable for a bank or financial institution to purchase insurance for heavy-tailed OpRisk losses under different insurance policy scenarios? The second question pertains to Solvency II and addresses quantification of insurer capital for such operational risk scenarios. Considering fundamental insurance policies available, in several two risk scenarios, we can provide both analytic results and extensive simulation studies of insurance mitigation for important basic policies, the intention being to address questions related to VaR reduction under Basel II, SCR under Solvency II and fair insurance premiums in OpRisk for different extreme loss scenarios. In the process we provide closed-form solutions for the distribution of loss processes and claims processes in an LDA structure as well as closed-form analytic solutions for the Expected Shortfall, SCR and MCR under Basel II and Solvency II. We also provide closed-form analytic solutions for the annual loss distribution of multiple risks including insurance mitigation.

SENDOV, H. S., WANG, Y. & ZITIKIS, R. *Log-supermodularity of weight functions, ordering weighted losses, and the loading monotonicity of weighted premiums.* 257–264. The paper is motivated by a problem concerning the monotonicity of insurance premiums with respect to their loading parameter: the larger the parameter, the larger the insurance premium is expected to be. This property, usually called the loading monotonicity, is satisfied by premiums that appear in the literature. The increased interest in constructing new insurance premiums has raised a question as to what weight functions would produce loading-monotonic premiums. In this paper, we



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demonstrate a decisive role of log-supermodularity or, equivalently, of total positivity of order 2 (TP2) in answering this question. As a consequence, we establish–at a stroke–the loading monotonicity of a number of well-known insurance premiums, and offer a host of further weight functions, and consequently of premiums, thus illustrating the power of the herein suggested methodology for constructing loading-monotonic insurance premiums.

WOO, J-K. *Refinements of two-sided bounds for renewal equations*. 189–196. Many quantities of interest in the study of renewal processes may be expressed as the solution to a special type of integral equation known as a renewal equation. The main purpose of this paper is to provide bounds for the solution of renewal equations based on various reliability classifications. Exponential and nonexponential types of inequalities are derived. In particular, two-sided bounds with specific reliability conditions become sharp. Finally, some examples including ultimate ruin for the classical Poisson model with time-dependent claim sizes, the joint distribution of the surplus prior to and at ruin, and the excess life time, are provided.

ZHENG, Y., YANG, J. & HUANG, J. Z. *Approximation of bivariate copulas by patched bivariate Fréchet copulas*. 246–256. Bivariate Fréchet (BF) copulas characterize dependence as a mixture of three simple structures: comonotonicity, independence and countermonotonicity. They are easily interpretable but have limitations when used as approximations to general dependence structures. To improve the approximation property of the BF copulas and keep the advantage of easy interpretation, we develop a new copula approximation scheme by using BF copulas locally and patching the local pieces together. Error bounds and a probabilistic interpretation of this approximation scheme are developed. The new approximation scheme is compared with several existing copula approximations, including shuffle of min, checkmin, checkerboard and Bernstein approximations and exhibits better performance, especially in characterizing the local dependence. The utility of the new approximation scheme in insurance and finance is illustrated in the computation of the rainbow option prices and stop-loss premiums.

## Insurance: Mathematics & Economics

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BAUERLE, N. & BLATTER, A. *Optimal control and dependence modeling of insurance portfolios with Lévy dynamics*. 398–405. In this paper we are interested in optimizing proportional reinsurance and investment policies in a multidimensional Lévy-driven insurance model. The criterion is that of maximizing exponential utility. Solving the classical Hamilton–Jacobi–Bellman equation yields that the optimal retention level keeps a constant amount of claims regardless of time and the company's wealth level. A special feature of our construction is to allow for dependencies of the risk reserves in different business lines. Dependence is modeled via an Archimedean Lévy copula. We derive a sufficient and necessary condition for an Archimedean Lévy generator to create a multidimensional positive Lévy copula in arbitrary dimension. Based on these results we identify structure conditions for the generator and the Lévy measure of an Archimedean Lévy copula under which an insurance company reinsures a larger fraction of claims from one business line than from another.

BERDEL, J. & HIPP, C. *Convolutions of multivariate phase-type distributions*. 374–377. This paper is concerned with multivariate phase-type distributions introduced by Assaf et al. (1984).



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We show that the sum of two independent bivariate vectors each with a bivariate phase-type distribution is again bivariate phase-type and that this is no longer true for higher dimensions. Further, we show that the distribution of the sum over different components of a vector with multivariate phase-type distribution is not necessarily multivariate phase-type either, if the dimension of the components is two or larger.

BRUHN, K. & STEFFENSEN, M. *Household consumption, investment and life insurance.* 315–325. This paper develops a continuous-time Markov model for utility optimization of households. The household optimizes expected future utility from consumption by controlling consumption, investments and purchase of life insurance for each person in the household. The optimal controls are investigated in the special case of a two-person household, and we present graphics illustrating how differences between the two persons affect the controls.

CAIRNS, A. J. G., BLAKE, D., DOWD, K., EPSTEIN, D., KHALAF-ALLAH, M. & COUGHLAN, G. D. *Mortality density forecasts: An analysis of six stochastic mortality models.* 355–367. This paper develops a framework for developing forecasts of future mortality rates. We discuss the suitability of six stochastic mortality models for forecasting future mortality and estimating the density of mortality rates at different ages. In particular, the models are assessed individually with reference to the following qualitative criteria that focus on the plausibility of their forecasts: biological reasonableness; the plausibility of predicted levels of uncertainty in forecasts at different ages; and the robustness of the forecasts relative to the sample period used to fit the model. An important, though unsurprising, conclusion is that a good fit to historical data does not guarantee sensible forecasts. We also discuss the issue of model risk, common to many modelling situations in demography and elsewhere. We find that even for those models satisfying our qualitative criteria, there are significant differences among central forecasts of mortality rates at different ages and among the distributions surrounding those central forecasts.

CHEUNG, E. C. K. *A generalized penalty function in Sparre Andersen risk models with surplus-dependent premium.* 384–397. In a general Sparre Andersen risk model with surplus-dependent premium income, the generalization of Gerber–Shiu function proposed by Cheung et al. (2010a) is studied. A general expression for such Gerber–Shiu function is derived, and it is shown that its determination reduces to the evaluation of a transition function which is independent of the penalty function. Properties of and explicit expressions for such a transition function are derived when the surplus process is subject to (i) constant premium; (ii) a threshold dividend strategy; or (iii) credit interest. Extension of the approach is discussed for an absolute ruin model with debit interest.

CHI, Y. & LIN, X. SHELDON. *On the threshold dividend strategy for a generalized jump–diffusion risk model.* 326–337. In this paper, we generalize the Cramér–Lundberg risk model perturbed by diffusion to incorporate jumps due to surplus fluctuation and to relax the positive loading condition. Assuming that the surplus process has exponential upward and arbitrary downward jumps, we analyze the expected discounted penalty (EDP) function of Gerber and Shiu (1998) under the threshold dividend strategy. An integral equation for the EDP function is derived using the Wiener–Hopf factorization. As a result, an explicit analytical expression is obtained for the EDP function by solving the integral equation. Finally, phase-type downward jumps are considered and a matrix representation of the EDP function is presented.

GOMEZ-DENIZ, E., SARABIA, J. M. & CALDERÍN-OJEDA, E. *A new discrete distribution with actuarial applications.* 406–412. A new discrete distribution depending on two parameters, $a < 1$,



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a 0 and 0 < < 1, is introduced in this paper. The new distribution is unimodal with a zero vertex and overdispersion (mean larger than the variance) and underdispersion (mean lower than the variance) are encountered depending on the values of its parameters. Besides, an equation for the probability density function of the compound version, when the claim severities are discrete is derived. The particular case obtained when a tends to zero is reduced to the geometric distribution. Thus, the geometric distribution can be considered as a limiting case of the new distribution. After reviewing some of its properties, we investigated the problem of parameter estimation. Expected frequencies were calculated for numerous examples, including short and long tailed count data, providing a very satisfactory fit.

LU, Z. & MENG, L. *Stochastic comparisons for allocations of policy limits and deductibles with applications*. 338–343. In this paper, we study the problem of comparing losses of a policyholder who has an increasing utility function when the form of coverage is policy limit and deductible. The total retained losses of a policyholder [formula] are ordered in the usual stochastic order sense when Xi(i = 1,…,n) are ordered with respect to the likelihood ratio order. The parallel results for the case of deductibles are obtained in the same way. It is shown that the ordering of the losses are related to the characteristics (log-concavity or log-convexity) of distributions of the risks. As an application of the comparison results, the optimal problems of allocations of policy limits and deductibles are studied in usual stochastic order sense and the closed-form optimal solutions are obtained in some special cases.

MIHALYKO, E. O. & MIHALYKO, C. *Mathematical investigation of the Gerber–Shiu function in the case of dependent inter-claim time and claim size*. 378–383. In this paper we investigate the well-known Gerber–Shiu expected discounted penalty function in the case of dependence between the inter-claim times and the claim amounts. We set up an integral equation for it and we prove the existence and uniqueness of its solution in the set of bounded functions. We show that if d > 0, the limit property of the solution is not a regularity condition, but the characteristic of the solution even in the case when the net profit condition is not fulfilled. It is the consequence of the choice of the penalty function for a given density function. We present an example when the Gerber–Shiu function is not bounded, consequently, it does not tend to zero. Using an operator technique we also prove exponential boundedness.

NAM, H. S., TANG, Q. & YANG, F. *Characterization of upper comonotonicity via tail convex order*. 368–373. In this paper, we show a characterization of upper comonotonicity via tail convex order. For any given marginal distributions, a maximal random vector with respect to tail convex order is proved to be upper comonotonic under suitable conditions. As an application, we consider the computation of the Haezendonck risk measure of the sum of upper comonotonic random variables with exponential marginal distributions.

SOTOMAYOR, L. R. & CADENILLAS, A. *Classical and singular stochastic control for the optimal dividend policy when there is regime switching*. 344–354. Motivated by economic and empirical arguments, we consider a company whose cash surplus is affected by macroeconomic conditions. Specifically, we model the cash surplus as a Brownian motion with drift and volatility modulated by an observable continuous-time Markov chain that represents the regime of the economy. The objective of the management is to select the dividend policy that maximizes the expected total discounted dividend payments to be received by the shareholders. We study two different cases: bounded dividend rates and unbounded dividend rates. These cases generate, respectively, problems of classical stochastic control with regime switching and singular



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stochastic control with regime switching. We solve these problems, and obtain the first analytical solutions for the optimal dividend policy in the presence of business cycles. We prove that the optimal dividend policy depends strongly on macroeconomic conditions.

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North American Actuarial Journal

14(3), 2010

BALLOTTA, L. *Efficient pricing of Ratchet Equity Indexed Annuities in a VG economy.* 355–368. In this paper we propose a new method for approximating the price of arithmetic Asian options in a Variance-Gamma (VG) economy, which is then applied to the problem of pricing equity-indexed annuity contracts. The proposed procedure is an extension to the case of a VG-based model of the moment-matching method developed by Turnbull and Wakeman and Levy for the pricing of this class of path-dependent options in the traditional Black-Scholes setting. The accuracy of the approximation is analyzed against RQMC estimates for the case of ratchet equity-indexed annuities with index averaging.

DOWD, K., CAIRNS, A. J. G., BLAKE, D., COUGHLAN, G. D., EPSTEIN, D. & KHALAF-ALLAH, M. *Backtesting Stochastic Mortality Models: An Ex-Post Evaluation of Multi-Period-Ahead Density Forecasts.* 281–298. This study sets out a backtesting framework applicable to the multiperiod-ahead forecasts from stochastic mortality models and uses it to evaluate the forecasting performance of six different stochastic mortality models applied to English & Welsh male mortality data. The models considered are the following: Lee-Carter's 1992 one-factor model; a version of Renshaw-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 Renshaw-Haberman; Cairns, Blake, and Dowd's 2006 two-factor model; and two generalized versions of the last named with an added cohort effect. For the data set used herein, the results from applying this methodology suggest that the models perform adequately by most backtests and that prediction intervals that incorporate parameter uncertainty are wider than those that do not. We also find little difference between the performances of five of the models, but the remaining model shows considerable forecast instability.

FREES, E. W. & SUN, Y. *Household Life Insurance Demand: a Multivariate Two-Part Model.* 338–354. What types of households own life insurance? Who owns term life and who owns whole life insurance? These are questions of great interest to insurers that operate in a highly competitive market. To answer these questions, we jointly examine household demand of two types of insurance, term and whole life, using data from the Survey of Consumer Finances, a probability sample of the U.S. population. We model both the frequency and the severity of demand for insurance, building on the work of Lin and Grace by using explanatory variables that they developed. For the frequency portion, the household decisions about whether to own term and whole life insurance are modeled simultaneously with a bivariate probit regression model. Given ownership of life insurance by a household, the amounts of insurance are analyzed using



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generalized linear models with a normal copula. The copula permits the bivariate modeling of insurance amounts for households who own both term and whole life insurance, about 20% of our sample. These models allow analysts to predict who owns life insurance and how much they own, an important input to the marketing process. Moreover, our findings suggest that household demand for term and whole life insurance is jointly determined. After controlling for explanatory variables, there exists a negative relationship for a household's decision to own both whole and term life insurance (the frequency part) and a positive relationship for the amount of insurance purchased (the severity part). This indicates that the greater the probability of holding one type, the smaller the probability of holding the other type of life insurance. However, higher demand for both types of insurance exists when a household decides to own both. This mixed effect extends prior work that established a negative relationship, suggesting that term life insurance and whole life insurance are substitutes for one another. In contrast, our findings reveal that the ownership decision involves substitution, but, for households owning both types of insurance, amounts are positively related. Therefore, term and whole life insurance are substitutes in the frequency yet complements in the severity.

MONTAMBEAULT, M. & MENARD, J-C. *Mortality Projections for Social Security Programs in Canada*. 316–337. Worldwide, the 20th century brought tremendous reductions in mortality at all ages for both males and females. The reductions in mortality, combined with the aging of the baby boomers and lower fertility rates, are projected to increase the proportion of the Canadian population that is above age 65 in the coming decades. This paper examines past mortality trends in Canada and discusses how these trends may change over the next 75 years, thus influencing the growth of the elderly population. In addition, this paper describes the methods and assumptions used to project future mortality rates in Canada, and the results include assumed annual rates of mortality improvement and projected life expectancies. As well, this paper discusses stochastic time-series methods that are used to help quantify the variability in the mortality rate projections.

WADE, A. H. *Mortality Projections for Social Security Programs in the United States*. 299–315. Worldwide, the twentieth century brought tremendous reductions in mortality at all ages for both males and females. The reductions in mortality, combined with the aging of the baby boomers and lower fertility rates, are projected to increase the proportion of the U.S. population that is above age 65 in the coming decades. This paper examines past mortality trends, discusses how these trends may change over the next 75 years, and analyzes implications of these trends for the growth of the elderly population. In addition, this paper describes the methods and assumptions used to project future mortality rates and presents results, including assumed annual rates of mortality reduction and projected life expectancies. It also discusses stochastic time-series methods that are used to help quantify the variability in the mortality rate projections.

North American Actuarial Journal

14(4), 2010

ALBRECHER, H., GERBER, H. U. & YANG, H. *A Direct Approach to the Discounted Penalty Function*. 420–447. This paper provides a new and accessible approach to establishing certain results concerning the discounted penalty function. The direct approach consists of two steps. In the first step, closedform expressions are obtained in the special case in which the claim amount distribution is a combination of exponential distributions. A rational function is useful in this



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context. For the second step, one observes that the family of combinations of exponential distributions is dense. Hence, it suffices to reformulate the results of the first step to obtain general results. The surplus process has downward and upward jumps, modeled by two independent compound Poisson processes. If the distribution of the upward jumps is exponential, a series of new results can be obtained with ease. Subsequently, certain results of Gerber and Shiu [H. U. Gerber and E. S. W. Shiu, North American Actuarial Journal 2(1): 48–78 (1998)] can be reproduced. The two-step approach is also applied when an independent Wiener process is added to the surplus process. Certain results are related to Zhang et al. [Z. Zhang, H. Yang, and S. Li, Journal of Computational and Applied Mathematics 233: 1773–1784 (2010)], which uses different methods.

DAYANANDA, P. W. A. & KEMPER, J. T. *Fair Terms and Fair Pricing for Multiple Warrant Issues*. 448–463. Some firms utilize one or more tranches of warrant issues to supplement their capital base. Unlike exchange-traded options, the exercise of warrants requires the issuance of stock by the company, resulting in a form of dilution. Some previous studies of warrant valuation relied on "the value of the firm," which is nonobservable, making it difficult to apply the corresponding valuation formula. This paper derives closed-form formulas to value single and multiple tranches of warrants based on the underlying stock price, its volatility, and other known parameter values. The paper first establishes the equivalence of the Black-Scholes formula for both call options and warrants in the case of a single tranche. Thereafter, it considers the impact on the value of previously issued warrants that results when a new tranche of warrants is subsequently issued, showing in each case that fair treatment of the first-issued warrant holders requires an adjustment (due to dilution) in the terms of those warrants and a corresponding modification in the warrants' value once a second tranche of warrants is issued. To promote such fair treatment, terms of a warrant indenture would specify the nature of the adjustment required when future warrants are issued or exercised, analogous to the antidilution terms related, for example, to stock dividends. Unlike multiple issues of traded options, which are valued independently of one another, multiple warrant issues will be shown to have prices dependent on other warrants outstanding. Also examined is the sensitivity of the fair-value adjustment to changes in the underlying variables, and the theoretical fair-value prices are compared with Black-Scholes prices and with market prices of warrants in the case of two publicly traded companies, each with two warrant issues outstanding. As warrant issues modify the equity structure of a firm, the methodology of valuing warrants presented here will be useful to investment actuaries in situations in which a comprehensive market value for all of a firm's securities is called for. In addition, risk management practices may sometimes include the use of warrant transactions to hedge stock positions similar to the way that call options are used for that purpose. This may include hedging the risk in equity-linked insurance contracts when the equity position includes stock in companies that have one or more warrant issues that are traded. The methods developed here are also applicable to multiple issues of executive stock options (ESOs) or to combinations of warrant issues and ESOs.

HURLIMANN, W. *Biometric Solvency Risk for Portfolios of General Life Contracts: I. The Single-Life Multiple Decrement Case*. 400–419. Solvency II splits life insurance risk into seven risk classes consisting of three biometric risks (mortality risk, longevity risk, and disability/morbidity risk) and four nonbiometric risks (lapse risk, expense risk, revision risk, and catastrophe risk). The best estimate liabilities for the biometric risks are valued with biometric life tables (mortality and disability tables), while those of the nonbiometric risks require alternative valuation methods. The present study is restricted to biometric risks encountered in traditional single-life insurance contracts with multiple causes of decrement. Based on the results of quantitative impact studies,



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process risk was deemed to be not significant enough to warrant an explicit calculation. It was therefore assumed to be implicitly included in the systematic/ parameter risk, resulting in a less complex standard formula. For the purpose of internal models and improved risk management, it appears important to capture separately or simultaneously all risk components of biometric risks. Besides its being of interest for its own sake, this leads to a better understanding of the standard approach and its application extent. Based on a total balance sheet approach we express the liability risk solvency capital of an insurance portfolio as value-at-risk and conditional value-at-risk of the prospective liability risk understood as random present value of future cash flows at a given time. The proposed approach is then applied to determine the biometric solvency capital for a portfolio of general life contracts. Using the conditional mean and variance of a portfolio's prospective liability risk and a gamma distribution approximation we obtain simple solvency capital formulas as well as corresponding solvency capital ratios. To account for the possibility of systematic/parameter risk, we propose either to shift the biometric life tables or to apply a stochastic biometric model, which allows for random biometric rates. A numerical illustration for a cohort of immediate life annuities in arrears reveals the importance of process risk in the assessment of longevity risk solvency capital.

JIANG, S-J. *Voluntary Termination of Life Insurance Policies: Evidence from the U.S. Market.* 369–380. In this paper, one error-correction model (ECM) that is able to avoid the problem of producing noise within traditional multiple cointegration vectors has been employed to explore the dynamics of surrender behavior. The evidence shows that both the emergency fund hypothesis and interest rate hypothesis are sustained in the short run as well as in the long run. A unique cointegration relationship within the surrender dynamics has been validated. In addition, a new hypothesis test that stresses the competition for the withdrawal of life insurance policy cash values has also been conducted. Such a crowding-out effect between policy loans and policy surrenders might be attributed to the motivation that keeps a life policy in force, the existence of surrender charges, and the automatic premium loan provision.

LI, J. S-H., HARDY, M. R. & TAN, K. S. *Developing mortality improvement formulas: the Canadian insured lives case study.* 381–399. Longevity improvements have contributed to widespread underfunding of pension plans and losses in insured annuity portfolios. Insurers might reasonably expect some upside from the effect of lower mortality on their life business. Although mortality improvement scales, such as the Society of Actuaries Scale AA, are widely employed in pension and annuity valuation, the derivation of these scales appears heuristic, leading to problems in deriving meaningful measures of uncertainty. We explore the evidence on mortality trends for the Canadian life insurance companies, data, using stochastic models. We use the more credible population data to benchmark the insured lives data. Finally, we derive a practical, model-based formula for actuaries to incorporate mortality improvement and the associated uncertainty into their calculations.

YU, K., REN, J. & STANFORD, D. A. *The Moments of the Time of Ruin in Markovian Risk Models.* 464–471. We present an approach based on matrix-analytic methods to find moments of the time of ruin in Markovian risk models. The approach is applicable when claims occur according to a Markovian arrival process (MAP) and claim sizes are phase distributed with parameters that depend on the state of the MAP. The method involves the construction of a sample-path-equivalent Markovmodulated fluid flow for the risk model. We develop an algorithm for moments of the time of ruin and prove the algorithm is convergent. Examples show that the proposed approach is computationally stable.



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Scandinavian Actuarial Journal

4, 2010

ADAMIC, P., DIXON, S. & GILLIS, D. *Multiple decrement modeling in the presence of interval censoring and masking*. 312–327. A self-consistent algorithm will be proposed to non-parametrically estimate the cause-specific cumulative incidence functions (CIFs) in an interval censored, multiple decrement context. More specifically, the censoring mechanism will be assumed to be a mixture of case 2 interval-censored data with the addition possibility of exact observations. The proposed algorithm is a generalization of the classical univariate algorithms of Efron and Turnbull. However, unlike any previous non-parametric models proposed in the literature to date, the algorithm will explicitly allow for the possibility of any set of all possible causes. A simulation study is also conducted to demonstrate the consistency of the estimators of the CIFs produced by the proposed algorithm, as well as to explore the effect of masking. The paper concludes by applying the method to masked mortality data obtained for Pueblo County, CO, for three risks: death by cancer, cardiovascular failure, or other.

BIFFIS, E., DENUIT, M. & DEVOLDER, P. *Stochastic mortality under measure changes*. 284–311. We provide a self-contained analysis of a class of continuous-time stochastic mortality models that have gained popularity in the last few years. We describe some of their advantages and limitations, examining whether their features survive equivalent changes of measures. This is important when using the same model for both market-consistent valuation and risk management of life insurance liabilities. We provide a numerical example based on the calibration to the French annuity market of a risk-neutral version of the model proposed by Lee & Carter (1992).

PSARRAKOS, G. *Some results on the joint distribution prior to and at the time of ruin in the classical model*. 268–283. For the classical risk model (i.e. with Poisson arrivals), we study the tail of the joint distribution of the surplus prior to and at ruin. In particular, we obtain some inequalities and monotonicity results for it. Let S be the random variable with distribution function the probability of non-ruin, [….], and […] the probability the surplus just before ruin exceeds x, given that ruin occurs. We estimate the distance between the residual lifetime of S, […] and the product […], where the tail convolution includes again the random variable S. finally, based on this distance, we derive a lower bound for the probability of ruin, and we compare this against a bound available in the literature.

VERNIC, R., DHAENE, J. & SUNDT, B. *Inequalities for the De Pril approximation to the distribution of the number of policies with claims*. 249–267. In the present paper, we give sufficient conditions for an ordering of De Pril approximations of the distributions of the number of claims in an insurance portfolio of independent policies. Possible extensions are discussed, both for the De Pril approximation and the Kornya approximation. A numerical example is given.



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South African Actuarial Journal

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MAITLAND, A. J. *A multiple Markov switching model for actuarial use in South Afri*ca. 71–108. This paper introduces a new class of Markov switching models where switches in variables are not perfectly correlated. Maximum-likelihood estimates of the parameters are derived and shown to require only the smoothed inferences obtained from a univariate analysis of the variables. The framework is used to estimate a multiple Markov switching (MMS) model of South African financial and economic variables, which can be used for various actuarial applications, especially those involving long-term projections. Users may wish to set certain parameters in relation to future expectations rather than simply using estimates based on past data, but that process is not covered in this paper. KEYWORDS Multivariate, multiple Markov switching, long-term, financial projections, actuarial, stochastic model, time-series models.

RAUBENHEIMER, H. & KRUGER, M. F. *Generating interest-rate scenarios for fixed-income portfolio optimisation.* 1–42. One of the main sources of uncertainty in the analysis of the risk and return properties of a portfolio of fixed-income securities is the stochastic evolution of the shape of the yield curve. The authors have estimated a model that fits the South African yield curve, using a Kalman filter. The model includes four latent factors and three observable macroeconomic variables (capacity utilisation, inflation and the repo rate). The goal is to capture the dynamic interactions between the macroeconomy and the yield curve in such a way that the resulting model can be used to generate interest-rate scenario trees that are suitable for fixed-income portfolio optimisation. An important input into the scenario generator is the investor's view on the future evolution of the repo rate. In this paper, details of the model are provided and the results of the estimation and scenario generation are reported. KEYWORDS Term structure; yield curve; Kalman filter; macroeconomic; scenario generation; Nelson–Siegel curve; Svensson curve.

RAUBENHEIMER, H. & KRUGER, M. F. *A stochastic-programming approach to integrated asset and liability management of insurance products with guarantees.* 43–70. In recent years insurance products have become more complex by providing investors with various guarantees and bonus options. This increase in complexity has provided an impetus for the investigation into integrated asset- and liability-management frameworks that could realistically address dynamic portfolio allocation in a risk-controlled way. In this paper the authors propose a multi-stage dynamic stochastic-programming model for the integrated asset and liability management of insurance products with guarantees that minimises the down-side risk of these products. They investigate with-profit guarantee funds by including regular bonus payments while keeping the optimisation problem linear. The uncertainty is represented in terms of arbitrage free scenario trees using a four-factor yield-curve model that includes macroeconomic factors (inflation, capacity utilisation and the repo rate). They construct scenario trees with path-dependent intermediate discrete yield-curve outcomes suitable for the pricing of fixed-income securities. The main focus of the paper is the formulation and implementation of a multi-stage stochastic programming model. The model is back-tested on real market data over a period of five years. KEYWORDS Minimum guarantees; asset and liability management; stochastic programming; portfolio optimisation.



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THOMSON, R. J. *Modelling the market in a risk-averse world: the case of South Afric*a. 109–36. In this paper, descriptive models of real returns on the South African market portfolio are developed and analysed. The 'market portfolio' is taken to comprise listed equity and government bonds, aggregated in proportion to their market capitalisation from time to time. The models have the attributes that, conditionally on information at the start of a year: – the real return on the market portfolio during that year is normally distributed; and – the market price of risk during that year is reasonably greater than zero. For the purpose of predictive modelling, the best of the models considered was found to be a linear function of the risk-free rate. For that purpose it was decided to use ex-ante estimates of expected returns. This led to bias in the observed mean returns, which negates the rational expectations hypothesis. In the light of the literature on the subject, this is considered acceptable for these purposes. KEYWORDS Market portfolio, risk aversion, South Africa, bias.

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