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ASTIN Bulletin

42 (1), 2012

ARBENZ, P.; CANESTRABO, D. *Estimating copulas for insurance from scarce observations, expert opinion and prior information: A Bayesian approach.* 271–290. A prudent assessment of dependence is crucial in many stochastic models for insurance risks. Copulas have become popular to model such dependencies. However, estimation procedures for copulas often lead to large parameter uncertainty when observations are scarce. In this paper, we propose a Bayesian method which combines prior information (e.g. from regulators), observations and expert opinion in order to estimate copula parameters and determine the estimation uncertainty. The combination of different sources of information can significantly reduce the parameter uncertainty compared to the use of only one source. The model can also account for uncertainty in the marginal distributions. Furthermore, we describe the methodology for obtaining expert opinion and explain involved psychological effects and popular fallacies. We exemplify the approach in a case study.

BÜHLMANN, H.; CZAPIEWSKI, C.; HAVNING, M.; JOHANSEN, S. *Obituary: Paul Johansen, the first Chairman of ASTIN has died.* 385–387. Obituary.

CHANG, C. W.; CHANG, J. S. K.; GUAN LIM, K. *Global warming, extreme weather events, and forecasting tropical cyclones.* 77–101. Global warming has more than doubled the likelihood of extreme weather events, e.g. the 2003 European heat wave, the growing intensity of rain and snow in the Northern Hemisphere, and the increasing risk of flooding in the United Kingdom. It has also induced an increasing number of deadly tropical cyclones with a continuing trend. Many individual meteorological dynamic simulations and statistical models are available for forecasting hurricanes but they neither forecast well hurricane intensity nor produce clear-cut consensus. We develop a novel hurricane forecasting model by straddling two seemingly unrelated disciplines — physical science and finance — based on the well known price discovery function of trading in financial markets. Traders of hurricane derivative contracts employ all available forecasting models, public or proprietary, to forecast hurricanes in order to make their pricing and trading decisions. By using transactional price changes of these contracts that continuously clear the market supply and demand as the predictor, and with calibration to extract the embedded hurricane information by developing hurricane futures and futures option pricing models, one can gain a forward-looking market-consensus forecast out of all of the individual forecasting models employed. Our model can forecast when a hurricane will make landfall, how destructive it will be, and how this destructive power will evolve from inception to

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landing. While the NHC (National Hurricane Center) blends 50 plus individual forecasting results for its consensus model forecasts using a subjective approach, our aggregate is market-based. Believing their proprietary forecasts are sufficiently different from our market-based forecasts, traders could also examine the discrepancy for a potential trading opportunity using hurricane derivatives. We also provide a real case analysis of Hurricane Irene in 2011 using our methodology.

DAHMS, R. *Linear stochastic reserving methods.* 1–34. In this article we want to motivate and analyse a wide family of reserving models, called linear stochastic reserving methods (LSRMs). The main idea behind them is the assumption that the (conditionally) expected changes of claim properties during a development period are proportional to exposures which depend linearly on the past. This means the discussion about the choice of reserving methods can be based on heuristic reasons about exposures driving the claims development, which in our opinion is much better than a pure philosophic approach. Moreover, the assumptions of LSRMs do not include the independence of accident periods. We will see that many common reserving methods, like the Chain-Ladder-Method, the Bornhuetter-Ferguson-Method and the Complementary-Loss-Ratio-Method, can be interpreted in this way. But using the LSRM framework you can do more. For instance you can couple different triangles via exposures. This leads to reserving methods which look at a whole bundle of triangles at once and use the information of all triangles in order to estimate the future development of each of them. We will present unbiased estimators for the expected ultimate and estimators for the mean squared error of prediction, which may become an integral part of IFRS 4. Moreover, we will look at the one period solvency reserving risk, which already is an important part of Solvency II, and present a corresponding estimator. Finally we will present two examples that illustrate some features of LSRMs.

DELONG, L. *No-good-deal, local mean-variance and ambiguity risk pricing and hedging for an insurance payment process.* 203–232. We study pricing and hedging for an insurance payment process. We investigate a Black-Scholes financial model with stochastic coefficients and a payment process with death, survival and annuity claims driven by a point process with a stochastic intensity. The dependence of the claims and the intensity on the financial market and on an additional background noise (correlated index, longevity risk) is allowed. We establish a general modeling framework for no-good-deal, local mean-variance and ambiguity risk pricing and hedging. We show that these three valuation approaches are equivalent under appropriate formulations. We characterize the price and the hedging strategy as a solution to a backward stochastic differential equation. The results could be applied to pricing and hedging of variable annuities, surrender options under an irrational lapse behavior and mortality derivatives.

DESMEDT, S.; SNOUSSI, M.; CHENUT, X.; WALHIN, J. F. *Experience and exposure rating for property per risk excess of loss reinsurance revisited.* 233–270. Experience and exposure rating are traditionally considered to be independent but complementary methods for pricing property per risk excess of loss reinsurance. Strengths and limitations of these techniques are well-known. In practice, both methods often lead to quite different prices. In this paper we show that limitations of traditional experience rating can be overcome by taking into account historical profile information by means of exposure curves. For pricing unused or rarely used capacity, we propose to use exposure rating, calibrated on the experience rate of a working layer. We compare the method presented with more traditional methods based on the information which is generally available to the reinsurer.

HERAS, A.; BALBÁS, B.; VILAR, J. L. *Conditional tail expectation and premium calculation.* 325–342. In this paper we calculate premiums which are based on the minimization of the Expected Tail Loss or Conditional Tail Expectation (CTE) of absolute loss functions. The methodology generalizes well known premium calculation procedures and gives sensible results in practical applications. The choice of the absolute loss becomes advisable in this context since its CTE is easy to calculate and to understand in intuitive terms. The methodology also can be applied to the calculation of the VaR and CTE of the loss associated with a given premium.

KALUSZKA, M.; KRZESZOWIEC, M. *Mean-Value Principle under Cumulative Prospect Theory.* 103–122. In the paper we introduce a generalization of the mean-value principle under Cumulative Prospect Theory. This new method involves some well-known ways of pricing insurance contracts described in the actuarial literature. Properties of this premium principle, such as translation and scale invariance, additivity for independent risks, risk loading and others are studied.

LANDSMAN, Z.; TSANAKAS, A. *Parameter uncertainty in exponential family tail estimation.* 123–152. Actuaries are often faced with the task of estimating tails of loss distributions from just a few observations. Thus estimates of tail probabilities (reinsurance prices) and percentiles (solvency capital requirements) are typically subject to substantial parameter uncertainty. We study the bias and MSE of estimators of tail probabilities and percentiles, with focus on 1-parameter exponential families. Using asymptotic arguments it is shown that tail estimates are subject to significant positive bias. Moreover, the use of bootstrap predictive distributions, which has been proposed in the actuarial literature as a way of addressing parameter uncertainty, is seen to double the estimation bias. A bias corrected estimator is thus proposed. It is then shown that the MSE of the MLE, the parametric bootstrap and the bias corrected estimators only differ in terms of order $O(n^{-2})$, which provides decision-makers with some flexibility as to which estimator to use. The accuracy of asymptotic methods, even for small samples, is demonstrated exactly for the exponential and related distributions, while other 1-parameter distributions are considered in a simulation study. We argue that the presence of positive bias may be desirable in solvency capital calculations, though not necessarily in pricing problems.

LEE, S. C. K.; LIN, X. S. *Modeling dependent risks with multivariate Erlang mixtures.* 153–180. In this paper, we introduce a class of multivariate Erlang mixtures and present its desirable properties. We show that a multivariate Erlang mixture could be an ideal multivariate parametric model for insurance modeling, especially when modeling dependence is a concern. When multivariate losses are governed by a multivariate Erlang mixture, many quantities of interest such as joint density and Laplace transform, moments, and Kendall's tau have a closed form. Further, the class is closed under convolutions and mixtures, which enables us to model aggregate losses in a straightforward way. We also introduce a new concept called quasi-comonotonicity that can be useful to derive an upper bound for individual losses in a multivariate stochastic order and upper bounds for stop-loss premiums of the aggregate loss. Finally, an EM algorithm tailored to multivariate Erlang mixtures is presented and numerical experiments are performed to test the efficiency of the algorithm.

LU, Y.; ZENG, L. *A nonhomogeneous Poisson hidden Markov model for claim counts.* 181–202. We propose a nonhomogeneous Poisson hidden Markov model for a time series of claim counts that accounts for both seasonal variations and random fluctuations in the claims intensity. It assumes that the parameters of the intensity function for the nonhomogeneous Poisson distribution vary

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according to an (unobserved) underlying Markov chain. This can apply to natural phenomena that evolve in a seasonal environment. For example, hurricanes that are subject to random fluctuations (El Niño-La Niña cycles) affect insurance claims. The Expectation-Maximization (EM) algorithm is used to calculate the maximum likelihood estimators for the parameters of this dynamic Poisson hidden Markov model. Statistical applications of this model to Atlantic hurricanes and tropical storms data are discussed.

MARTÍNEZ MIRANDA, M. D.; NIELSEN, J. P.; VERRALL, R. *Double chain ladder.* 59–76. By adding the information of reported count data to a classical triangle of reserving data, we derive a surprisingly simple method for forecasting IBNR and RBNS claims. A simple relationship between development factors allows to involve and then estimate the reporting and payment delay. Bootstrap methods provide prediction errors and make possible the inference about IBNR and RBNS claims, separately.

NAKANO, Y. *On approximating law-invariant comonotonic coherent risk measures.* 343–353. The optimal quantization theory is applied for approximating law-invariant comonotonic coherent risk measures. Simple L^p-norm estimates for the risk measures provide the rate of convergence of that approximation as the number of quantization points goes to infinity.

ROSENLUND, S. *Bootstrapping individual claim histories.* 291–324. The bootstrap method BICH is given for estimating mean square prediction errors and predictive distributions of non-life claim reserves under weak conditions. The dates of claim occurrence, reporting and finalization and the payment dates and amounts of individual finalized historic claims form a claim set from which samples with replacement are drawn. We assume that all claims are independent and that the historic claims are distributed as the object claims, possibly after inflation adjustment and segmentation on a background variable, whose distribution could have changed over time due to portfolio change. Also we introduce the new reserving function RDC, using all these dates and payments for reserve predictions. We study three reserving functions: chain ladder, the Schnieper (1991) method and RDC. Checks with simulated cases obeying the assumptions of Mack (1999) for chain ladder and Liu and Verrall (2009) for Schnieper's method, respectively, confirm the validity of our method. BICH is used to compare the three reserving functions, of which RDC is found overall best in simulated cases.

SALZMANN, R.; WÜTHRICH, M. V.; MERZ, M. *Higher moments of the claims development result in general insurance.* 355–384. The claims development result (CDR) is one of the major risk drivers in the profit and loss statement of a general insurance company. Therefore, the CDR has become a central object of interest under new solvency regulation. In current practice, simple methods based on the first two moments of the CDR are implemented to find a proxy for the distribution of the CDR. Such approximations based on the first two moments are rather rough and may fail to appropriately describe the shape of the distribution of the CDR. In this paper we provide an analysis of higher moments of the CDR. Within a Bayes chain ladder framework we consider two different models for which it is possible to derive analytical solutions for the higher moments of the CDR. Based on higher moments we can e.g. calculate the skewness and the excess kurtosis of the distribution of the CDR and obtain refined approximations. Moreover, a case study investigates and answers questions raised in IASB [9].

VERRALL, R.; HÖSSJER, O.; BJÖRKWALL, S. *Modelling claims run-off with reversible jump Markov chain Monte Carlo methods.* 35–58. In this paper we describe a new approach to

modelling the development of claims run-off triangles. This method replaces the usual ad hoc practical process of extrapolating a development pattern to obtain tail factors with an objective procedure. An example is given, illustrating the results in a practical context, and the WinBUGS code is supplied.

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BAUER, D.; REUSS, A.; SINGER, D. *On the calculation of the solvency capital requirement based on nested simulations*. 453–499. Within the European Union, risk-based funding requirements for insurance companies are currently being revised as part of the Solvency II project. However, many life insurers struggle with the implementation, which to a large extent appears to be due to a lack of know-how regarding both, stochastic modeling and efficient techniques for the numerical implementation. The current paper addresses these problems by providing a mathematical framework for the derivation of the required risk capital and by reviewing different alternatives for the numerical implementation based on nested simulations. In particular, we seek to provide guidance for practitioners by illustrating and comparing the different techniques based on numerical experiments.

CHEUNG, K. C.; LIU, F.; YAM, S. C. P. *Average value-at-risk minimizing reinsurance under Wang's premium principle with constraints*. 575–600. In the present work, we study the optimal reinsurance decision problem in which the Average Value-at-Risk of the retained loss is minimized under Wang's premium principle and is also subject to either (1) a budget constraint on reinsurance premium, or (2) a reinsurer's probabilistic benchmark constraint of his potential loss. We show that the optimal reinsurance is a single-insurance layer under Constraint (1), and a cap insurance or a double-insurance layer under Constraint (2); moreover, under Constraint (2), we further establish that under most common circumstances (see Remark after Theorem 3), a cap insurance will suffice to be optimal. Finally, some numerical illustrations will be provided.

CHI, Y.; LIN, X. S. *Are flexible premium variable annuities under-priced?* 559–574. A variable annuity (VA) is a deferred annuity that allows an annuitant to invest his/her contributions into a range of mutual funds. A separate account termed as sub-account is set up for the investment. Unlike a mutual fund, a VA offers a guaranteed minimum death benefit or GMDB and often offers a guaranteed minimum living benefit or GMLB during the accumulation phase of the VA contract. Almost all the research to date has focused on single premium variable annuities (SPVAs), i.e. it is assumed that an annuitant makes a single lump-sum contribution at the time of issue. In this paper, we study flexible premium variable annuities (FPVAs) that allow contributions during the accumulation phase. We derive a valuation formula for guarantees embedded in FPVAs and show that the delta hedging strategy for an FPVA is substantially different from that for an SPVA. The numerical examples illustrate that the cost in the form of mortality and expense (M&E) fee for an FPVA in many situations is significantly higher than the cost for a similar SPVA. This finding suggests that the current pricing practice by most VA providers that charges the same M&E fee for both should be re-examined.

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CHI, Y. *Reinsurance arrangements minimizing the risk-adjusted value of an insurer's liability.* 529–557. In this paper, we investigate the problem of purchasing a reinsurance policy that minimizes the risk-adjusted value of an insurer's liability, where the valuation is carried out using a cost-of-capital approach. In order to exclude the moral hazard, we assume that both the insurer and reinsurer are obligated to pay more for larger loss in a typical reinsurance treaty. Moreover, the reinsurance premium principle is assumed to satisfy three axioms: law invariance, risk loading and preserving convex order. The proposed class of premium principles is quite general in the sense that it contains all the widely used premium principles except Esscher principle listed in Young (2004). When capital at risk is measured by the value at risk (VaR) or conditional value at risk (CVaR), we find it is optimal for the insurer to cede two separate layers over the prescribed premium principles. By imposing an additional weak constraint on the premium principle, we further get that the reinsurance in the form of a layer is optimal. Finally, to illustrate the applicability of our results, we derive explicitly the optimal one-layer reinsurance for expected value principle and Wang's premium principle, and show that two-layer reinsurance may be optimal for Dutch premium principle.

GÓMEZ-DÉNIZ, E.; SARABIA, J. M.; BALAKRISHNAN, K. *A multivariate discrete Poisson-Lindley distribution extensions and actuarial applications.* 655–678. This paper proposes multivariate versions of the continuous Lindley mixture of Poisson distributions considered by Sankaran (1970). This new class of distributions can be used for modelling multivariate dependent count data when marginal overdispersion is present. After discussing some of its properties, a general multivariate model with Poisson-Lindley marginals and with a flexible covariance structure is proposed. Several specific models as well as one that allows correlations of any sign are considered, and then some estimation methods are discussed. Finally, some illustrative examples are given for fitting and demonstrating the usefulness of these bivariate distributions.

HUA, LEI; JOE, HARRY. *Tail comonotonicity and conservative risk measures.* 601–629. Tail comonotonicity, or asymptotic full dependence, is proposed as a reasonable conservative dependence structure for modeling dependent risks. Some sufficient conditions have been obtained to justify the conservativity of tail comonotonicity. Simulation studies also suggest that, by using tail comonotonicity, one does not lose too much accuracy but gain reasonable conservative risk measures, especially when considering high scenario risks. A copula model with tail comonotonicity is applied to an auto insurance dataset. Particular models for tail comonotonicity for loss data can be based on the BB2 and BB3 copula families and their multivariate extensions.

INGRAM, D.; TAYLER, P.; THOMPSON, M. *Surprise, surprise: From neoclassical economics to e-life.* 389–411. We build and describe an agent-based model: the Surprise Game. The game comprises a 'world' of 30 firms, each of which has to survive (and, if possible, prosper) in its environment, which is nothing more than the other 29 firms. Each firm has to latch onto one or other of the four strategies that are predicted by the theory of plural rationality but has to relinquish that strategy and latch onto one of the others if it finds itself surprised. This model illustrates the dynamics of the world as described by the theory of plural rationality which are more similar to the dynamics of the actual world than economic models that assume equilibriums that are occasionally disturbed by shocks. This model and the theory of plural rationality provide insights and ideas for further work for actuaries.

PARK, S. C.; LEMAIRE, J. *The impact of culture on the demand for non-life insurance.* 501–527. Regression techniques are applied to an unbalanced panel data that includes 68 countries observed over a ten-year period, to explore the factors that affect non-life insurance demand across

nations. While previous literature has discovered several significant economic, demographic, and institutional variables, little attention has been devoted to cultural dimensions. We find that non-life insurance consumption is adversely impacted in countries where a large fraction of the population has Islamic beliefs. Also highly significant are three of the cultural scores developed by Hofstede in a celebrated study: Power Distance, Individualism, and Uncertainty Avoidance. An important finding is that culture impacts non-life insurance more in affluent countries, with an adjusted R-square coefficient increasing by 11.7%, than in developing countries where the R-square coefficient increase due to cultural impacts is only 1.2%. These results have implications for multinational insurers seeking to enter a new market. Ceteris Paribus, these insurers should target countries, and population segments within these countries, that exhibit low Power Distance, and high Individualism and Uncertainty Avoidance scores.

PSARRAKOS, G.; POLITIS, K. *The covariance between the surplus prior to and ruin in the classical risk model.* 631–653. For the classical model of risk theory, we consider the covariance between the surplus prior to and at ruin, given that ruin occurs. A general expression for this covariance is given when the initial surplus u is zero, and we show that the covariance (and hence the correlation coefficient) between these two variables is positive, zero or negative according to the equilibrium distribution of the claim size distribution having a coefficient of variation greater than, equal to, or less than one. For positive values of u, the formula for the covariance may not always lead to explicit results and we thus also study its asymptotic behaviour. Our results are illustrated by a number of examples.

SIU-HANG LI, J.; LUO, A. *Key Q-Duration: A framework for hedging Longevity Risk.* 413–452. When hedging longevity risk with standardized contracts, the hedger needs to calibrate the hedge carefully so that it can effectively reduce the risk. In this article, we present a calibration method that is based on matching mortality rate sensitivities. Specifically, we introduce a measure called key q-duration, which allows us to estimate the price sensitivity of a life-contingent liability to each portion of the underlying mortality curve. Given this measure, one can easily construct a longevity hedge with a small number of q-forward contracts. We further propose an extension for hedging the longevity risk associated with multiple birth cohorts, and another extension for accommodating population basis risk.

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Australian Actuarial Journal

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BOGGESS, M.; MOYER, M. *Error in joint mortality formulas.* 67–80. Life Contingencies is the study of probability and the time value of money whose objective is the valuation of quantities

associated with life insurance and annuities. Since policies on a husband and wife are common, actuarial exams covering life contingencies include the situation where the lifetimes of the husband and wife are dependent and the policy payout depends on the time of the first or second death. We show that some well-known formulas are incorrect, and whose application by the Society of Actuaries in their solutions to exam questions has led to incorrect answers. These formulas can be rectified by the inclusion of notation that makes specific the necessary conditioning events.

PRIEST, C. *Premium liability correlations and systemic risk*. 1–66. During the past decade many insurance solvency standards have introduced a requirement to use premium liabilities and diversified risk margins. With the introduction of IFRS 4, most countries' accounting standards augmented unearned premium provisions with premium liabilities. Many countries' accounting standards have also required the inclusion of diversified risk margins in premium liability provisions. Calculating diversified risk margins requires estimates, correlations and variances of the outstanding claims and premium liabilities. This paper shows how the application of a random effects model to claims payments can be used to unify the estimation of outstanding claims provisions and premium liability provisions, including the estimation of correlations between outstanding claims and premium liability. Estimators are proposed for the model parameters. While the model parameters are estimated using aggregated historical data, the model applies to individual claims, because premium liabilities are a subset of each data point in the aggregate data given in claims triangles, and thus an individual claim model is required to obtain the scaling of mean and variance.

STREET, A. *A house or a home? Finding value in Australian residential property*. 81–123. Australian house prices have experienced significant growth over the past 10 years and on a number of measures the market appears overvalued. This paper outlines and assesses the arguments used to justify current prices. Rather than structural factors (such as population growth and housing supply) being the main elements supporting current house prices, the alternative view is that cyclical factors, essentially low interest rates and low unemployment, are the key factors currently keeping Australian house prices at their present levels. Analysis of the housing market from an investor's perspective also suggests that very optimistic assumptions of future house price growth and/or future rental growth are being factored into current market pricing. The strong economic conditions in Australia, reflected in the low unemployment rate, should protect the Australian housing market from a US-style housing collapse in the short term, but in the longer term increasing unemployment will inevitably cause some correction in house prices.

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BALASOORIYA, U.; LI, J.; LEE, Y. S. *Mispriced risk in insurance and financial markets: Causes and consequences*. 191–220. In actuarial modelling, certain statistical tests, such as Pearson's chi-square test, are commonly used for evaluating the goodness of fit. Besides these standard tests, occasionally the limited-value averages (LVAs) are also examined for such purposes and are compared, in a rather casual manner, with the corresponding limited-value expectations under

the specified distribution law. In fact, as there are often coverage limits in practice, the LVAs are probably more relevant to the dollar values involved in the losses. In this article, we explore the application of a formal statistical setting of the LVAs test for goodness-of-fit testing. We apply it to the well-known hurricane loss data and also another set of individual claims data. Two simulation experiments are carried out to study the limiting chi-square property and the power of the test. A formal proof of the limiting property is provided in the appendix. Our results suggest that this LVAs test is potentially suitable for wider use in actuarial practice.

FERRIS, S. *Mispriced risk in insurance and financial markets: Causes and consequences.* 125–190. Theoretically, insurance should be beneficial to society. But in practice, insurance systems may become dysfunctional, creating an excessive increase in systemic risk which is detrimental to society. In this paper we use a historical example to illustrate the typical features of a dysfunctional insurance market and construct a model of risk-taking behaviour. We draw parallels with the more recent problems in the credit risk insurance market, which contributed to a sharp increase in systemic risk prior to the Global Financial Crisis in 2008/2009. Construction of a model facilitates assessment of some proposals for reforms.

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European Actuarial Journal

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BEN SALAH, Z.; MORALES, ML. *Lévy systems and the time value of ruin for Markov additive processes.* 289–317. In this paper we study the ruin problem for an insurance risk process driven by a spectrally-positive Markov additive process. Particular attention is given to the family of spectrally-positive Markov-modulated Lévy processes. We give an expression for the expected discounted penalty function by extending results available in the literature. In particular, we generalize some results in E Biffis and A Kyprianou (Insurance Mathematics & Economics 46:85–91, 2010) to a more general setting provided by the theory of Markov additive processes. This natural extension is possible thanks to the concept of Lévy systems that allows us to generalize well-known results for Lévy processes to a larger family of Markov additive processes. We also discuss how more compact expressions for the expected discounted penalty function can be obtained using the notion of scale matrix of a Markov additive process.

DHAENE, J.; KUKUSH, A.; LINDERS, D.; TANG, Q. *Remarks on quantiles and distortion risk measures.* 319–328. Distorted expectations can be expressed as weighted averages of quantiles. In this note, we show that this statement is essentially true, but that one has to be careful with the correct formulation of it. Furthermore, the proofs of the additivity property for distorted expectations of a comonotonic sum that appear in the literature often do not cover the case of a general distortion function. We present a straightforward proof for the general case, making use of the appropriate expressions for distorted expectations in terms of quantiles.

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GAILLARDETZ, P.; LI, H. Y.; MACKAY, A. *Equity-linked products: evaluation of the dynamic hedging errors under stochastic mortality.* 243–258. In this paper, we analyze the effect of unpredicted changes in mortality rates on the risk incurred by the sale of equity-indexed annuities (EIAs). Jumps in mortality indices due to catastrophes (for example, the 1918 flu pandemic) may occur in the future, causing important financial losses to insurers selling products offering death benefits. Thus, we analyze the distribution of hedging errors extracted from the dynamic hedging strategy underlying the fair valuation. To model mortality jumps stochastically, we use a regime-switching model introduced by A Milidonis et al. (North American Actuarial Journal 15(2):266–289, 2011). We then employ Esscher transforms to obtain closed-form expressions for the price of a term-end EIA at any time between the inception of the contract and its maturity date. The hedging strategy is derived from that valuation, and hedging errors are extracted from this strategy since it is not self-financing. A detailed numerical analysis is performed for a term-end EIA.

GERBER, H. U.; SHIU, E. S. W.; YANG, H. *The Omega model: from bankruptcy to occupation times in the red.* 259–272. Ruin occurs the first time when the surplus of a company or an institution is negative. In the Omega model, it is assumed that even with a negative surplus, the company can do business as usual until bankruptcy occurs. The probability of bankruptcy at a point of time only depends on the value of the negative surplus at that time. Under the assumption of Brownian motion for the surplus, the expected discounted value of a penalty at bankruptcy is determined, and hence the probability of bankruptcy. There is an intrinsic relation between the probability of no bankruptcy and an exposure random variable. In special cases, the distribution of the total time the Brownian motion spends below zero is found, and the Laplace transform of the integral of the negative part of the Brownian motion is expressed in terms of the Airy function of the first kind.

LÉVEILLÉ, G. *Bivariate compound renewal sums with discounted claims.* 273–288. Recursive moments, joint moments, moments generating functions, distribution functions, stop-loss premiums and risk measures have been found for the univariate compound renewal sums with discounted claims, for a constant force of real interest. More recently, moments and joint moments have also been found when the force of interest is stochastic. In this paper, we extend some of the preceding results to the bivariate compound renewal sums with discounted claims by first presenting a lemma that gives the conditional joint distribution of the occurrence times of the claims given the number of claims of each type up to time t, result that will be used to get the second moment, the first joint moment and other quantities related to our bivariate risk process.

MOUATASSIM, Y.; EZZAHID, E. H. *Poisson regression and zero-inflated Poisson regression: application to private health insurance data.* 187–204. Modeling event counts is important in many fields. For this purpose, the Poisson regression model is often used. However, this model assumes the equidispersion of the data. Unfortunately, this assumption is often violated in the observed data. The source of overdispersion depends on many situations. When the source of overdispersion is the excess of zeroes, the Zero-inflated Poisson regression model fits better counts data. In this paper, we first review the theoretical framework of Poisson regression and Zero-inflated Poisson regression. The probability integral transform test and the Vuong's test are used to compare between the two models. Second, we fit these models to the number of claims in a private health insurance scheme. In our case, the number of claims is overdispersed because of the preponderance of zeroes in the data set. The results prove that Zero-inflated Poisson

regression performs better the number of claims of the customers affiliated in the health insurance scheme in the Moroccan case.

PLANCHET, F.; GUIBERT, Q.; JUILLARD, M. *Measuring uncertainty of solvency coverage ratio in ORSA for non-life insurance.* 205–226. We apply a simple model to project the Solvency Capital Requirement (SCR) over several years, using an Own Risk Solvency Assessment (ORSA) perspective, in order to assess the probability of achieving a solvency coverage ratio. To do so, we rely on a simplified framework proposed in Guibert (Bulletin Français d'Actuariat 10(20), 2010) which provides a detailed explanation of the SCR. Then, we take into account temporal dynamics for liabilities, premiums and asset returns. Here, we consider guarantees in non-life insurance. This context, when simplified, allows us to use a lognormal distribution to approximate the distribution of the liabilities. It leads to a simple and tractable model for measuring the uncertainty of the solvency ratio in an ORSA perspective.

SALZMANN, R.; WÜTHRICH, M. V. *Modeling accounting year dependence in runoff triangles.* 227–242. Typically, non-life insurance claims data is studied in claims development triangles which display the two time axes accident years and development years. Most stochastic claims reserving models assume independence between different accident years. Therefore, such models fail to model claims inflation appropriately, because claims inflation acts on all accident years simultaneously. We introduce a Bayes chain ladder reserving model which enables us to model claims inflation. In this model we derive analytical formulas for the posterior distribution, the claims reserves and their prediction uncertainty.

SCHERER, M.; SCHMID, L.; SCHMIDT, T. *Shot-noise driven multivariate default models.* 161–186. The recent financial crisis, responsible for massive accumulations of credit events, emphasizes the urgent need for adequate portfolio default models. Due to the high dimensionality of real credit portfolios, balancing flexibility and numerical tractability is of uttermost importance. To acknowledge this, a multivariate default model with interesting stylized properties is introduced in the following way: a non-decreasing shot-noise process serves as common stochastic clock. Individual default times are defined as the first-passage times of the common clock across independent exponentially distributed threshold levels. We obtain a default model which has a dynamic stochastic representation, contagion effects, a positive probability for joint defaults, the ability to separate univariate marginal laws from the dependence structure, and the option for efficient pricing routines under a "large homogeneous groups" assumption. Besides this, the model is well-suited for insurance portfolios which are subject to catastrophe risks and the pricing of catastrophe derivatives.

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BAJO DAVÓ, N.; MENDOZA RESCO, C.; MONJAS BARROSO, M. *Portfolio diversification with life settlements: an empirical analysis applied to mutual funds.* 22–42. This article examines the formation of efficient portfolios using mutual funds that invest in life settlements in

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combination with fixed-income and equity index funds. We investigate the optimal weighting of these assets and their contribution to performance and portfolio risk. We find a significant negative correlation between the selected life settlement funds and certain U.S. and European fixed-income and equity funds. Furthermore, these correlations are lower than the correlations between the index funds that replicate each other. These results suggest that life settlement funds are an appropriate financial instrument to achieve greater diversification for a portfolio made up of a fund of funds and to improve fund performance as they provide a fixed return with a lower level of risk.

CONNELLY, L. B.; BUTLER, J. R. G. *Erratum to: Insurance rebates, incentives and primary care in Australia.* 181. Australia has a universal, compulsory, public health insurance scheme that includes insurance rebates for private fee-for-service medical practitioner services. Recent sweeping changes to the rebates for general practitioner (GP) services provide an opportunity to observe the effects of widespread insurance changes on the behaviour of GPs and aggregate outcomes such as quantities, prices and co-payments. In this paper, we study the effect of two important changes to subsidies for GP services, the first of which increased the rebates payable for services provided to specific patient groups, and the second of which increased rebates payable for all patients. Using economic theory, predictions of the effect of the rebate increase on quantities, prices and co-payments are produced that depend on the structure of the market. Using time-series data, we then present short-run empirical evidence that suggests that the supply curve for GP services is backward-bending.

GHOSH, A. *Life insurance in India: the relationship between reforms and growth in business.* 88–112. Reforms in the Indian life insurance sector began in 1999 and since then the growth of the life business has been impressive despite some restrictions. Whether the reforms in this sector have helped the industry to grow or not is an empirical matter. We, therefore, studied the relationship between life insurance sector reforms in India and the growth of life business in the post-reform period. At the empirical level, we first construct an index to measure the reforms and then used the VAR–VECM model to find out the long-run relationship. The Granger causality test suggests that life insurance sector reforms improved the overall development of life insurance development in recent years in India.

KRAUS, C. *EVA/RAROC vs. MCEV earnings: a unification approach.* 113–136. This paper compares different performance metrics used for value-based management in life and non-life insurance business. The goal is to find a consistent basis for performance measurement at the insurance group level. This is important since management techniques used in non-life insurance, such as economic value added and risk-adjusted return on capital, are at first sight very different from those used in life insurance, that is, an analysis of market-consistent embedded value earnings, thus making management difficult at the group level. This paper aims to compare and contrast these concepts and to show that all approaches can be unified under a single consistent framework, and that all present residual cash flow concepts that can be linked under the residual income valuation theory.

MA, Y.-L.; POPE, N.; YEUNG, R. *Foreign participation and its relationship with non-life insurer performance in the northeast Asian markets.* 43–61. This research examines the relationship shared by a national insurance market's competitive structure and insurer profitability. For these purposes, a market's competitive structure is defined by the level of foreign presence and market concentration. The analysis focuses on the four major non-life insurance markets of Asia: Japan,

the People's Republic of China, South Korea and Taiwan. The analysis tests hypotheses derived from the broad body of theory generally referred to as the structure-conduct-performance (SCP) hypothesis. The methodological approach makes a significant improvement over previous related work in that it also includes insurer-level data in additional to market-level control variables. In doing so, this research holds out the potential for consideration in the development of insurer-specific strategies in light of a potential influx of foreign competitors. The key findings of this research include general support for the expectations of the SCP hypothesis that predicts dominant firms in concentrated markets will drive up product price and generate associated higher levels of profit.

OLAOSEBIKAN, O. *The determinants of the profitability of micro-life insurers in Nigeria.* 140–159. Drawing a framework from the financial economics literature and utilising a dynamic panel data design covering 2004–2009, this study examines the profitability of micro-life insurers in Nigeria. The results indicate that the profitability of micro-life insurers is not influenced by factors such as the ownership structure, leverage and size of firms. However, profitability is found to be negatively related to the level of reinsurance suggesting that reinsurance in the micro-life insurance sector of the Nigerian market may be highly priced to reflect the increased risk associated with insuring the lives of low income groups. The link between profitability and the degree to which micro-life insurers have a diversified range of products suggests that multi-product firms are better able to reduce the cost of risk in-house through "natural diversification" as well as realise benefits from economies of scale and scope. Furthermore, the profitability of micro-life insurers operating in Nigeria is found to be positively influenced by the level of interest rates in the economy. This implies that the investment function and macroeconomic factors could be important in assessing the future financial performance of micro-insurance firms in developing countries. Finally, the results of the study could have potentially important commercial and public policy implications.

PARK, S. C.; TOKUTSUNE, Y. *Do Japanese policyholders care about insurers' credit quality?* 1–21. We analyse abnormal growth of premiums surrounding financial strength rating changes for a panel of life insurers in Japan during 2002–2009. Unlike the U.S. market, our regression results indicate that life insurance premiums do not show relevant change in connection with ratings changes in the Japanese market. However, insurance demand is not totally insensitive to the financial strength of insurers. We find that the demand for foreign life insurers has a positive relationship with solvency margin ratio. We also find that consumers cared more about insurers' credit quality during the later sample period of 2006–2009 than the earlier sample period of 2002–2005.

SLIWINSKI, A.; MICHALSKI, T.; ROSZKIEWICZ, M. *Demand for life insurance — an empirical analysis in the case of Poland.* 62–87. This paper presents the results of a study of the determination of life insurance demand in Poland. A characterisation of the Polish life insurance sector is given, including a comparison with the top ten emerging markets and other CEE countries such as Hungary and the Czech Republic. The characterisation is followed by a review of the previous studies of life insurance determinants. Subsequently, factor analysis is applied to distinguish independent factors that determine demand for life insurance. Then a linear regression model is used to identify both the factors that have determined life insurance in Poland and the extent thereof. However, as opposed to previous studies of life insurance demand, only distinguished factors are used as an independent variable. The study confirms that factors of an economic and financial nature strongly stimulate the demand for life insurance, which agrees

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with previous studies. However, some results contradict the previous findings such as the factor that includes variables such as education level and social benefits.

YAO, Y. *Development and sustainability of emerging health insurance markets: evidence from microinsurance in Pakistan.* 160–180. Despite widespread interest in expanding insurance at the bottom of the economic pyramid, the viability of emerging microinsurance programmes is questioned because of their high loss ratios and doubts about their sustainability. The purpose of this research is to derive implications for the viable provision of products for emerging microinsurers by investigating the degree of sustainability of a micro health insurance programme in its early years of development. Using data from a micro health insurance programme in Pakistan, this paper analyses how claim rates evolve as households renew their policies and finds that households that have larger claims during the policy period are more likely to renew their policies for the next period. Although on the surface that pattern is consistent with adverse selection and decreasing sustainability, it was found instead that when compared with households buying the insurance for the first time, renewed households have significantly lower claim frequency and total claim amounts. Taken together, these results may suggest that there are forces affecting insurance demand for renewed households that may lead to an improved risk portfolio.

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CHENG, J.; WEISS, M. A. *Risk-based capital and firm risk taking in property-liability insurance.* 274–307. This research investigates the relationship between capital and risk in property-liability insurers from 1993 to 2007. Three-stage least squares estimation is used to investigate the relationship between capital and two types of risk: underwriting and asset risk. Overall the results suggest that risk and capital are positively related, so that capital increases are associated with increases in investment and underwriting risk. This positive relationship was not consistently significant in 1993, prior to the implementation of risk-based capital (RBC) requirements. Both under-capitalised insurers and marginally adequately capitalised insurers adjusted their capital and risk towards firm targets at a higher speed than well-capitalised insurers in the post-RBC period. But underwriting and asset risk also increased for less well-capitalised insurers.

ETLING, M.; HOLDER, S. *Maximum technical interest rates in life insurance in Europe and the United States: an overview and comparison.* 354–375. We compare the regulatory environment for the maximum technical interest rate of life insurance contracts in four European countries and the United States. In Germany, Austria and Switzerland, the maximum rate is driven by a long-term rolling average of government bond yields and is adjusted by the regulator. In the U.S., corporate bond yields are used and the regulator is not directly involved in setting the maximum rate. The regime implemented in the United Kingdom is unique: instead of a rules-based "one-size-fits-all" approach, the maximum rate is determined by a company-specific principle-based method. We provide a comparative analysis of the different systems and conduct a numerical analysis to investigate how the maximum rate will develop under predefined interest rate scenarios. The discussion is highly relevant in light of Solvency II, a regime that may fundamentally change regulation of the maximum technical interest rate.

FLOREANI, A. *Risk measures and capital requirements: a critique of the Solvency II approach.* 189–212. In this paper the Solvency II VaR-based capital requirement is analysed and discussed.

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The new European risk-based system of prudential regulation for insurers could in fact increase, and not decrease, the fragility of the insurance industry. More specifically, the VaR capital requirement exposes insurance companies to a potentially huge systemic effect, as the bigger/ better diversified insurers have high default probabilities in case of market shortfalls. This paper shall suggest and discuss some adjustments to the current Solvency II framework.

HÖRING, D. *Will Solvency II market risk requirements bite? The impact of Solvency II on insurers' asset allocation.* 250–273. The European insurance industry is among the largest institutional investors in Europe. Therefore, major reallocations in their investment portfolios due to the new risk-based economic capital requirements introduced by Solvency II would cause significant disruptions in European capital markets and corporate financing. This paper studies whether the new regulatory capital requirements for market risk are a binding constraint for European insurers by comparing the required market risk capital of the Solvency II standard model with the Standard & Poor's rating model for a fictitious, but representative, European-based life insurer. The results show that for a comparable level of confidence, the rating model requires 68 per cent more capital than the standard model for the same market risks. Hence, Solvency II seems not to be a binding capital constraint for market risk and thus would not significantly influence the insurance companies' investment strategies.

KREUTZER, M.; WAGNER, J. *New solvency regulation: what CEOs of insurance companies think.* 213–249. Current reforms of solvency regulation in Europe include the Swiss Solvency Test, already in force in Switzerland since 2011, and the planned move by the European Union from the Solvency I to the Solvency II framework over the coming years. These changes bring with them more stringent requirements in many areas and thus have a broad impact on the European insurance industry. The scope of this paper is to analyse, on the basis of an industry survey, the perceived magnitude of the impact, the effects and the uncertainty accompanying these reforms. The study highlights significant differences in perception by country, size of business and dominant business line. Furthermore, selected perceived effects of new solvency regulation are shown to have a significant impact on the (planned) sites and scope of business model adaptation.

NGUYEN, T.; MOLINARI, P. *Accounting for "Insurance Contracts" according to IASB Exposure Draft — is the information useful?* 376–398. The International Accounting Standards Board (IASB, former IASC) has been working on a new international standard for insurance contracts based on fair value for about 10 years now. However, details on how to measure such a value in practice were unclear for a long time. A first indication of how an accounting model for insurance liabilities could look like was given by the Discussion Paper from May 2007 and concretised with the publication of the IASB Exposure Draft "Insurance Contracts". This paper aims to analyse the extent to which the accounting model for insurance liabilities introduced in the Exposure Draft is qualified to generate useful information to users of financial statements. Furthermore, we give recommendations about which fields need further adjustments in order to comply with decision usefulness as the overriding principle.

PAETZMANN, K.; LIPPI, C. *Accounting for European insurance M&A transactions: fair value of insurance contracts and duplex IFRS/U.S. GAAP purchase accounting.* 332–353. IFRS requires that for purchase accounting purposes, insurance liabilities are measured at their "fair value". Purchase accounting for insurance contracts proves to be a challenging topic for standard setters, preparers, and users, given the absence of specific guidance in IFRS for this particular case.

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Recent developments, in particular the 2010 IFRS Insurance Contract Exposure Draft, the 2010 Solvency II QIS 5 Technical Specifications and the 2009 Market Consistent Embedded Value (MCEV) Principles, may be seen as providing relevant techniques in this context but do not present clear guidance specifically for fair values as required for purchase accounting purposes. This paper compares fair value as required for purchase accounting within the current IFRS Phase II process, the proposed Solvency II regulations and the practical actuarial concept of MCEV. Potential investors may benefit from this as discretionary elements in M&A transaction accounting, and their implications should be taken into account early in the transaction process of insurance companies.

SIEGEL, C. *Solvency assessment for insurance groups in the United States and Europe — a comparison of regulatory frameworks.* 308–331. As a reaction to the increasing trend of insurers forming and participating in financial conglomerates and insurance groups, supervisory authorities are currently developing group-wide solvency regulations. The International Association of Insurance Supervisors (IAIS) recently published an issues paper that discusses the challenges to group supervision and defines criteria for a thorough group solvency framework. Based on these criteria, this article provides an overview and comparison of three important approaches—the U.S. solo-plus approach of the National Association of Insurance Commissioners, Switzerland's group structure model and the Solvency II Directive on Group Solvency Assessment. The analysis reveals various deficits within the group regulation of the United States implying the need for future regulatory work. By contrast, the performance of the European frameworks with regard to the IAIS criteria is good. In particular, the Swiss framework can be seen as a prime example of an innovative and solid group solvency assessment.

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DOHERTY, N. *Risk and the endogenous economist: Some comparisons of the treatment of risk in physics and economics.* 1–22. This is a talk, rather than a research or survey paper. Very little of what I say will be original, but I wish to stimulate discussion on a set of issues that arise from the nature of risk and that I consider problematic to our profession. The paper is not exhaustive of references and many of my arguments have been treated elsewhere. However, I suspect few will have approached the issues from the same starting point and assembled them in the same way.

LI, C.-S.; LIU, C.-C.; PENG, S.-C. *Expiration dates in automobile insurance contracts: The curious case of last policy month claims in Taiwan.* 23–47. This paper investigates a widespread trend in the Taiwanese automobile insurance market in which the loss claims of vehicle damage insurance contracts have a high propensity to occur just before the end of the policy year (as opposed to calendar year). We show that certain uncommon characteristics of claim data are consistently observed in the last policy month. We indirectly show that there is a severe time-varying excess claim problem in this market. The major sources of excess claims can be explained by the bonus-malus system problem and the auto-dealer incentive issue.

PICARD, P. PINQUET, J. *Optimal Risk Financing in Large Corporations through Insurance Captives*. 48–86. A captive is an insurance or reinsurance company established by a parent group to finance its own risks. Captives mix internal risk pooling between the business units of the parent group and risk transfer towards the reinsurance market. We analyse captives from an optimal insurance contract perspective. The paper characterises the vertical contractual chain that links firstly business units to insurance captives or to "fronters" through insurance contracts, secondly fronters to reinsurance captives through the cession of risks and thirdly insurance or reinsurance captives to reinsurers through cessions or retrocessions. In particular, the risk cession by fronters to a reinsurance captive trades off the benefits derived from recouped premiums and from the risk-sharing advantage of an "umbrella reinsurance policy", against the risks that result from the captive liabilities.

RIAHI, D.; LEVY-GARBOUA, L.; MONTMARQUETTE, C. *Competitive Insurance Markets and Adverse Selection in the Lab*. 87–113. We provide an experimental analysis of competitive insurance markets with adverse selection. Our parameterised version of the lemons' model of Akerlof in the insurance context predicts total crowding-out of low risks when insurers offer a single full insurance contract. The therapy proposed by Rothschild and Stiglitz consists of adding a partial insurance contract so as to obtain self-selection of risks. We test the theoretical predictions of these two models in two experiments. A clean test is obtained by matching the parameters of these experiments and by controlling for the risk neutrality of insurers and the common risk aversion of their clients by means of the binary lottery procedure. The results reveal a partial crowding-out of low risks in the first experiment. Crowding-out is not eliminated in the second experiment and it is not even significantly reduced. Finally, instead of the predicted separating equilibrium, we find pooling equilibria. The latter can be sustained because insureds who objectively differ in their risk level do not perceive themselves as being so much different.

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AVANZI, B.; CHEUNG, E. C. K.; WONG, B.; WOO, J.-K. *On a periodic dividend barrier strategy in the dual model with continuous monitoring of solvency*. 98–113. We consider the dual model, which is appropriate for modeling the surplus of companies with deterministic expenses and stochastic gains, such as pharmaceutical, petroleum or commission-based companies. Dividend strategies for this model that can be found in the literature include the barrier strategy (e.g. B Avanzi, H U Gerber, E S W Shiu (2007), Optimal dividends in the dual model, Insurance: Mathematics and Economics, 41(1): 111–123) and the threshold strategy (e.g. E C K Cheung (2008), Discussion on A Badescu and D Landriault's Recursive calculation of the dividend moments in a multi-threshold risk model, North American Actuarial Journal, 12(3): 336–340) where dividend decisions are made continuously. While in practice the financial position of a company is typically monitored frequently, dividend decisions are only made periodically along with the publication of its books. In this paper, we introduce a dividend barrier strategy whereby

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dividend decisions are made only periodically, but still allow ruin to occur at any time (as soon as the surplus is exhausted). This is in contrast to Albrecher et al. (2011a) [H Albrecher, E C K Cheung and S Thonhauser (2011), Randomized observation periods for the compound Poisson risk model: dividends, ASTIN Bulletin, 41(2): 645–672], who introduced periodic dividend payments in the Cramér-Lundberg surplus model, albeit with periodic ruin opportunities as well. Under the assumption that the time intervals between dividend decisions are distributed, we derive integro-differential equations for the Laplace transform of the time to ruin and the expected present value of dividends until ruin. These are then solved with the help of probabilistic arguments. We also provide a recursive algorithm to compute these quantities. Finally, some numerical studies are presented, which aim at illustrating how our assumptions about dividend payments and ruin occurrence compare with those of the classical barrier strategy.

BO, L.; SONG, R.; TANG, D.; WANG, T.; YANG, X. *Erratum to "Lévy risk model with two-sided jumps and a barrier dividend strategy"* 124–125. In this note, we point out some errors in Section 3 of our earlier paper "Lévy risk model with two-sided jumps and a barrier dividend strategy" published in Insurance: Mathematics and Economics, 50(2): 280–291, 2012. Specifically, we find that the optimal barrier does not depend on the initial surplus.

BOYER, M. M.; STENTOFT, L. *If we can simulate it, we can insure it: an application to longevity risk management.* 35–45. This paper proposes a unified framework for measuring and managing longevity risk. Specifically, we develop a flexible framework for valuing survivor derivatives like forwards, and swaps, as well as options both of European and American style. Our framework is essentially independent of the assumed underlying dynamics and the choice of method for risk neutralization and relies only on the ability to simulate from the risk neutral process. We provide an application to derivatives on the survivor index when the underlying dynamics are from a Lee-Carter model. Our results show that taking the optionality into consideration is important from a pricing perspective.

CHIU, M. C.; WONG, H. Y. *Optimal investment for an insurer with cointegrated assets: CRRA utility.* 52–64. This paper considers the optimal investment problem for an insurer that invests in cointegrated assets subject to the random payments of insurance claims. The insurer's objective is to maximize the expected utility of the terminal wealth subject to the cointegration dynamics of risky assets and the risk of paying out random liabilities with a compound Poisson process. We solve the continuous-time investment problems for the class of the constant relative risk averse utility [CRRA] function using the framework of the HJB equation. An explicit solution is derived by recognizing an exponential affine form in the derivation process. We then investigate the risk-preference of insurers toward statistical arbitrage from pairs-trading using the analytical results. Although a financial market with cointegrated risky assets implies the existence of statistical arbitrage opportunities, insurers may not be interested in those opportunities due to the social responsibility of a high level of risk aversion. However, if insurers are forced to trade cointegrated assets, the derived optimal solution enhances the investment performance.

CHRISTIANSEN, M. C.; DENUIT, M. M. *Worst-case actuarial calculations consistent with single- and multiple-decrement life tables.* 1–5. The present work complements the recent paper by Barz and Müller (2012) [C. Barz, A. Müller, Comparison and bounds for functionals of future lifetimes consistent with life tables, Insurance: Mathematics and Economics, 50 (2012), pp. 229–235]. Specifically, upper and lower bounds are derived for the force of mortality when one-year death probabilities are given, assuming a monotonic, convex or concave shape.

Based on these bounds, worst-case scenarios are derived depending on the mix of benefits in the case of survival and of death comprised in a specific insurance policy.

DONNELLY, C.; GUILLÉN, M.; NIELSEN, J. P. *Exchanging uncertain mortality for a cost*. 65–76. We analyze a pooled annuity fund from a participant's perspective by comparing it to a mortality-linked fund, a type of variable payout life annuity, that gives a return linked to the force of mortality but subject to a cost. Fixing the instantaneous volatility of return on wealth, we find that the expected return on the pooled annuity fund is higher except when the costs are very low in the mortality-linked fund. Similar results are obtained when maximizing the expected lifetime utility of consumption, assuming a constant relative risk aversion utility function. In both settings, our results indicate that a participant may be willing to accept the mortality risk of the pooled annuity fund, even when only 100 individuals are pooling their mortality in the pooled annuity fund.

HANEWALD, K.; PIGGOTT, J.; SHERRIS, M. *Individual post-retirement longevity risk management under systematic mortality risk*. 87–97. This paper analyzes an individual's post-retirement longevity risk management strategy allowing for systematic longevity risk, recent product innovations, and product loadings. A complete-markets discrete state model and multi-period simulations of portfolio strategies are used to assess individual longevity insurance product portfolios with different levels of systematic and idiosyncratic longevity risk. Portfolios include: fixed life annuities, deferred annuities, inflation-indexed annuities, phased withdrawals and recently proposed group self-annuitization (GSA) plans. GSA plans are found to replace even inflation-indexed annuity products when there are loadings on guaranteed life annuity products. With a bequest motive and loadings, coinsurance portfolio strategies with phased withdrawals and GSA's dominate portfolios with life annuities or deferred annuities.

IVANOVS, J. *A note on killing with applications in risk theory*. 29–34. It is often natural to consider defective or killed stochastic processes. Various observations continue to hold true for this wider class of processes yielding more general results in a transparent way without additional effort. We illustrate this point with an example from risk theory by showing that the ruin probability for a defective risk process can be seen as a triple transform of various quantities of interest on the event of ruin. In particular, this observation is used to identify the triple transform in a simple way when either claims or interarrivals are exponential. We also show how to extend these results to modulated risk processes, where exponential distributions are replaced by phase-type distributions. In addition, we review and streamline some basic exit identities for defective Lévy and Markov additive processes.

LU, Z.; LIU, L.; MENG, S. *Optimal reinsurance with concave ceded loss functions under VaR and CTE risk measures*. 46–51. Most of the studies on optimal reinsurance are from the viewpoint of the insurer and the optimal ceded functions always turn out to be convex. However reinsurance contracts always involve a limit on the ceded loss function in practice, thus it may not be enough to confine the analysis to the class of convex functions only. In this paper, we study the problem of optimal reinsurance under VaR [value-at-risk] and CTE [conditional tail expectation] optimization criteria when the ceded loss functions are in the class of increasing concave functions. By using a simple geometric approach, we prove that under the VaR optimization criterion, the quota-share reinsurance with a policy limit is always optimal, while the full reinsurance with a policy limit is optimal under the CTE optimization criterion. Some illustrative examples are presented.

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NOWAK, P.; ROMANIUK, M. *Pricing and simulations of catastrophe bonds*. 18–28. The increasing number of natural catastrophes like floods, hurricanes, and earthquakes not only causes many victims, but also leads to severe production, infrastructure, and individual property losses. Classic insurance mechanisms may be inadequate for dealing with such losses because of the dependencies that exist, inter alia, between the sources of the losses, the huge values of claims, and problems with adverse selection and moral hazard. To cope with the dramatic consequences of extreme events, new financial and insurance instruments are required. One example of a catastrophe-linked security is the catastrophe bond (cat bond), also known as the Act-of-God bond. In this paper we price some catastrophe bonds. We apply models of the risk-free spot interest rate under the assumption that the occurrence of the catastrophe is independent of financial market behavior. We then use Monte Carlo simulations to analyze the numerical properties of the pricing formulas thus obtained. We make a twofold contribution to the literature of catastrophe bond pricing. First, we prove a general pricing formula, which can be applied to cat bonds with different payoff functions under the assumption of different models of the risk-free spot interest rate. Second, we price some new types of cat bonds with interest rate dynamics described by the CIR and the Hull-White model.

SHEN, Y.; SIU, T. K. *Longevity bond pricing under stochastic interest rate and mortality with regime-switching*. 114–123. We develop a flexible model to value longevity bonds which incorporates several important sources of risk, namely, interest rate risk, mortality risk and the risk due to structural changes in economic and environmental conditions. In particular, Markov, regime-switching, jump-diffusion models are used to describe stochastic movements of short-term interest rate and force of mortality. These models capture jumps in short rate and mortality rate and the impacts of economic and environmental fundamentals on their movements over time. Using the concept of stochastic flows, we derive an exponential affine form of the longevity bond price in the proposed joint stochastic interest rate and mortality models. In particular, a representation for the exponential affine form of the longevity bond price is obtained in terms of fundamental matrix solutions of linear, matrix-valued, ordinary differential equations.

TIONG, S. *Pricing inflation-linked variable annuities under stochastic interest rates*. 77–86. Equities have long been dubbed the natural hedge against inflation. However, empirical findings have implied just the opposite, that there exists a negative correlation between stock returns and inflation. The rising inflation and slowing economic growth that we are experiencing in today's market environment pose an even greater threat to the general investors, especially on their retirement planning. In this paper, we present various inflation-linked variable annuities which are designed to help investors protect their portfolios from inflation risk. Assuming a Gaussian HJM framework for the nominal and real term structures, closed-form pricing formulas are obtained for these inflation-linked annuity products.

YAO, H.; LAI, Y.; LI, Y. *Continuous-time mean-variance asset-liability management with endogenous liabilities*. 6–17. This paper investigates a continuous-time mean-variance asset-liability management problem with endogenous liabilities in a more general market where all the assets can be risky. Different from exogenous liabilities that cannot be controlled, the endogenous liabilities can be controlled by various financial instruments and investors' decisions. For example, a company can raise fund by issuing different kinds of bonds. Types and quantities of the bonds are controlled by the company itself. Investors optimize allocation not only for their assets, but also for their liabilities under our model. This makes the analysis of the problem more

challenging than in the setting based on exogenous liabilities. In this paper, we first prove the existence and uniqueness of the solution to the associated Riccati-type equation by using the Khatri-Rao product technique and the relevant stochastic control theory; we then derive closed form expressions of the efficient strategy and the mean-variance efficient frontier by using the Lagrange multiplier method and the Hamilton-Jacobi-Bellman equation approach, and we next discuss two degenerated cases; finally, we present some numerical examples to illustrate the results obtained in this paper.

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ALEMANY, R.; BOLANCÉ, C.; GUILLÉN, M. *A nonparametric approach to calculating value-at-risk*. 255–262. A method to estimate an extreme quantile that requires no distributional assumptions is presented. The approach is based on transformed kernel estimation of the cumulative distribution function (cdf). The proposed method consists of a double transformation kernel estimation. We derive optimal bandwidth selection methods that have a direct expression for the smoothing parameter. The bandwidth can accommodate to the given quantile level. The procedure is useful for large data sets and improves quantile estimation compared to other methods in heavy tailed distributions. Implementation is straightforward and R programs are available.

BARRIEU, P.; LOUBERGÉ, H. *Reinsurance and securitisation of life insurance risk: the impact of regulatory constraints*. 135–144. Large systematic risks, such as those arising from natural catastrophes, climatic changes and uncertain trends in longevity increases, have risen in prominence at a societal level and, more particularly, have become a highly relevant issue for the insurance industry. Against this background, the combination of reinsurance and capital market solutions (insurance-linked securities) has received an increasing interest. In this paper, we develop a general model of optimal risk-sharing among three representative agents — an insurer, a reinsurer and a financial investor, making a distinction between systematic and idiosyncratic risks. We focus on the impact of regulation on risk transfer, by differentiating reinsurance and securitisation in terms of their impact on reserve requirements. Our results show that different regulatory prescriptions will lead to quite different results in terms of global risk-sharing.

BELLES-SAMPERA, J.; MERIGÓ, J. M.; GUILLÉN, M.; SANTOLINO, M. *The connection between distortion risk measures and ordered weighted averaging operators*. 411–420. Distortion risk measures summarize the risk of a loss distribution by means of a single value. In fuzzy systems, the Ordered Weighted Averaging (OWA) and Weighted Ordered Weighted Averaging (WOWA) operators are used to aggregate a large number of fuzzy rules into a single value. We show that these concepts can be derived from the Choquet integral, and then the mathematical relationship between distortion risk measures and the OWA and WOWA operators for discrete and finite random variables is presented. This connection offers a new interpretation of distortion risk measures and, in particular, Value-at-Risk and Tail Value-at-Risk can be understood from an aggregation operator perspective. The theoretical results are illustrated in an example and the degree of orness concept is discussed.

CHEN, Z.; LI, G.; GUO, J.-E. *Optimal investment policy in the time consistent mean-variance formulation*. 145–156. As a necessary requirement for multi-period risk measure, time

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consistency can be examined from two aspects: dynamic risk measure and optimal investment policy. In this paper, we first study the relationship between the time consistency of dynamic risk measure and the time consistency of optimal investment policy and obtain the following conclusions: if the dynamic risk mapping is time consistent and monotone, then the corresponding optimal investment policy satisfies the time consistency requirements; however, if the dynamic risk mapping is time consistent but not monotone, then the time consistency requirements of an optimal investment policy will no longer be satisfied. Since the variance operator does not satisfy the smoothing property, the optimal investment policy derived from the existing multi-period mean–variance model is not time consistent. To overcome this shortcoming, we propose the notation of a separable expected conditional mapping and then construct a time consistent dynamic mean–variance model. We prove that the optimal investment policy derived from our model is time consistent. Moreover, for two cases with or without a riskless asset, we obtain the time consistent analytical optimal investment policy and the mean–variance efficient frontier of the new model with the self-financing constraint. Finally, numerical results illustrate the flexibility and superiority of our multi-period mean–variance model and the optimal investment policy over those in the literature.

CHI, Y.; TAN, K. S. *Optimal reinsurance with general premium principles*. 180–189. In this paper, we study two classes of optimal reinsurance models from the perspective of an insurer by minimizing its total risk exposure under the criteria of value at risk (VaR) and conditional value at risk (CVaR), assuming that the reinsurance premium principles satisfy three basic axioms: distribution invariance, risk loading and stop-loss ordering preserving. The proposed class of premium principles is quite general in the sense that it encompasses eight of the eleven commonly used premium principles listed in Young (2004) [V R Young. Premium principles, in J Teugels, B Sundt. (eds.), Encyclopedia of Actuarial Science (John Wiley & Sons, 2004)]. Under the additional assumption that both the insurer and reinsurer are obligated to pay more for larger loss, we show that layer reinsurance is quite robust in the sense that it is always optimal over our assumed risk measures and the prescribed premium principles. We further use the Wang's and Dutch premium principles to illustrate the applicability of our results by deriving explicitly the optimal parameters of the layer reinsurance. These two premium principles are chosen since in addition to satisfying the above three axioms, they exhibit increasing relative risk loading, a desirable property that is consistent with the market convention on reinsurance pricing.

GIGENTE, P.; PICECH, L.; SIGALOTTI, L. *Claims reserving in the hierarchical generalized linear model framework*. 381–390. We consider an approach based on the hierarchical generalized linear models and h-likelihood estimators for claims reserving in non-life insurance. The hierarchical generalized linear models represent a class of flexible mixture models that extend the generalized linear models and the generalized linear mixed models. The fitting algorithm and the inferential analyses can be obtained by applying standard procedures to one or more generalized linear models, suitably defined. Our study examines how the models can be used to obtain predictors of the claims reserves and to determine their prediction uncertainty.

GIJBELS, I.; SZNAJDER, D. *Testing tail monotonicity by constrained copula estimation*. 338–351. In this paper the interest is in testing for tail monotonicity dependence structures between two random variables. The main focus in the presentation of the statistical methodology is on left tail decreasingness, but the developed procedures can also be used for testing for other specific tail monotonicity dependence structures. In order to assess the p-values of the test statistic, we

resample from a constrained copula estimator. This can be done in a nonparametric or in a parametric way. The main difficulty is the construction of a constrained estimator and the development of a resampling technique. The finite-sample performances of the proposed testing procedures are investigated in a simulation study and illustrations on real data examples are provided.

GUPTA, P.; MITTAL, G.; MEHLAWAT, M. K. *Expected value multiobjective portfolio rebalancing model with fuzzy parameters.* 190–203. In this paper we develop a multicriteria credibilistic framework for portfolio rebalancing. We use an expected value model with fuzzy parameters considering return, risk and liquidity as key financial criteria. The transaction costs are assumed to be paid on the basis of incremental discounts and are adjusted in the net return of the portfolio. A solution procedure based on fuzzy goal programming and a hybrid intelligent algorithm that combines fuzzy simulation with a real-coded genetic algorithm is presented to solve the portfolio rebalancing problem. The approach adopted here has the advantage of handling the multicriteria portfolio rebalancing problem where the fuzzy parameters are characterized by general functional forms. An empirical study is included to demonstrate the effectiveness of the solution approach and efficiency of the model in practical applications of rebalancing an existing portfolio.

HATZOPOULOS, P.; HABERMAN, S. *Common mortality modeling and coherent forecasts. An empirical analysis of worldwide mortality data.* 320–337. A new common mortality modeling structure is presented for analyzing mortality dynamics for a pool of countries, under the framework of generalized linear models (GLM). The countries are first classified by fuzzy c-means cluster analysis in order to construct the common sparse age-period model structure for the mortality experience. Next, we propose a method to create the common sex difference age-period model structure and then use this to produce the residual age-period model structure for each country and sex. The time related principal components are extrapolated using dynamic linear regression (DLR) models and coherent mortality forecasts are investigated. We make use of mortality data from the "Human Mortality Database".

HE, L.; LIANG, Z. *Optimal dynamic asset allocation strategy for ELA scheme of DC pension plan during the distribution phase.* 404–410. In this paper, we study the optimal dynamic asset allocation strategy for the ELA [equity-linked annuity] scheme of DC [defined contribution] pension plan during the distribution phase. In an ELA scheme of DC pension plan, the assets are invested in equities and bonds, and are distributed to the plan participants by an actuarial method. The survived participant can also obtain a survival credit from the mortality risk-sharing implicit in the pension plan. The goal of the scheme is to maintain the stable purchasing power of the plan participants, i.e., to minimize the square deviations of the distribution and a predetermined level by choosing the optimal dynamic asset allocation proportions. We formalize the problem into a continuous-time stochastic optimal control problem and establish the optimal dynamic asset allocation strategy by stochastic dynamic programming method. We obtain the optimal dynamic asset allocation proportions invested in the equities and bonds, and give an economical explanation of the key factors influencing the strategy.

LI, S.; LU, Y. *On the generalized Gerber-Shiu function for surplus processes with interest.* 127–134. In this paper, we study the generalized expected discounted penalty (Gerber-Shiu) function in a risk process with credit and debit interests. We define $T_{u,z}$ to be the first time that the surplus process drops below a certain level z from the initial surplus $u(>z)$. The time of ruin and the time

of absolute ruin are special cases of this stopping time. The generalized Gerber–Shiu function is defined on three random variables: the first time that the surplus drops below z from u, $T_{u,z}$, the surplus prior to $T_{u,z}$, and the amount by which the surplus is below z. An explicit expression for the Gerber-Shiu function when $u = z$ is obtained when the credit and debit interest rates are equal, and explicit results for the Gerber-Shiu function under exponential claims are then obtained. Using these results, we investigate the probability that the surplus reaches an upper level without dropping below a lower level and the distribution of the maximum severity of ruin. [This abstract contains mathematical notation.]

MA, Z.-G.; MA, C.-Q. *Pricing catastrophe risk bonds: a mixed approximation method.* 243–254. This paper presents a contingent claim model similar to the one described by Lee and Yu (2002) [J-P Lee and M-T Yu, Pricing default-risky CAT bonds with moral hazard and basis risk, Journal of Risk and Insurance, 69 (1) (2002), pp. 25–44] for pricing catastrophe risk bonds. First, we derive a bond pricing formula in a stochastic interest rates environment with the losses following a compound nonhomogeneous Poisson process. Furthermore, we estimate and calibrate the parameters of the pricing model using the catastrophe loss data provided by Property Claim Services (PCS) from 1985 to 2010. As no closed-form solution can be obtained, we propose a mixed approximation method to find the numerical solution for the price of catastrophe risk bonds. Finally, numerical experiments demonstrate how financial risks and catastrophic risks affect the prices of catastrophe bonds.

MADAN, D. B.; SCHOUTENS, W. *Systemic risk tradeoffs and option prices.* 222–230. Two new indices for financial diversity are proposed. The first is aggregative and evaluates distance from a single factor driving returns. The second evaluates how fast correlation with a stock rises as the stock falls. Both measures are here risk neutral. The CRI [correlation response index] is also compared with coVaR [conditional value at risk]. These measures are negatively related and so focus attention on different aspects of systemic risk. Unlike the coVaR focused on expected losses the CRI measures the risks of increased correlation and lack of diversity in activities. The CRI also declined consistently for AIG and LEH prior to their bankruptcies indicating that the market was active in decorrelating itself from these firms.

MALINOVSKII, V. K. *Level premium rates as a function of initial capital.* 370–380. In Malinovskii (2012) [V K Malinovskii, Equitable solvent controls in a multi-period game model of risk, Insurance: Mathematics and Economics, 51(3): 599–616], level premium rate and level initial capital were used to construct solvent and equitable strategies in a multi-period game model of risk. Focused there was the level initial capital regarded as a function of the annual premium rate. With the prospective goal to study adaptive control strategies on falling competitive insurance markets, in this paper we focus on the level premium rate regarded as a function of initial capital.

MAO, B.; CARSON, J. M.; OSTASZEWSKI, K. M.; WEN, Z. *Optimal decision on dynamic insurance price and investment portfolio of an insurer.* 359–369. We establish a model of insurance pricing with the assumption that the insurance price, insurer investment returns, and insured losses are correlated stochastic processes. We consider the effect of demand on price where the objective of the pricing model is to maximize the expected utility of the insurer's terminal wealth. Based on a Hamilton-Jacobi-Bellman (HJB) equation, we simultaneously solve for the optimal price of an insurance contract and the optimal investment portfolio of an insurer. The results show that quantity demanded of insurance contracts affects the optimal allocation to

risky assets in the insurer's investment portfolio. Our results also show that the drift and volatility of the insurance price process will affect the investment strategy, in addition to the effect of the drift and volatility of the investment process itself.

MITCHELL, D.; BROCKETT, P.; MENDOZA-ARRIAGA, R.; MUTHURAMAN, K. *Modeling and forecasting mortality rates*. 275–285. We show that by modeling the time series of mortality rate changes rather than mortality rate levels we can better model human mortality. Leveraging on this, we propose a model that expresses log mortality rate changes as an age group dependent linear transformation of a mortality index. The mortality index is modeled as a Normal Inverse Gaussian. We demonstrate, with an exhaustive set of experiments and data sets spanning 11 countries over 100 years, that the proposed model significantly outperforms existing models. We further investigate the ability of multiple principal components, rather than just the first component, to capture differentiating features of different age groups and find that a two component NIG model for log mortality change best fits existing mortality rate data.

OWADALLY, I.; LANDSMAN, Z. *A characterization of optimal portfolios under the tail mean–variance criterion*. 213–221. The tail mean–variance model was recently introduced for use in risk management and portfolio choice; it involves a criterion that focuses on the risk of rare but large losses, which is particularly important when losses have heavy-tailed distributions. If returns or losses follow a multivariate elliptical distribution, the use of risk measures that satisfy certain well-known properties is equivalent to risk management in the classical mean–variance framework. The tail mean–variance criterion does not satisfy these properties, however, and the precise optimal solution typically requires the use of numerical methods. We use a convex optimization method and a mean–variance characterization to find an explicit and easily implementable solution for the tail mean–variance model. When a risk-free asset is available, the optimal portfolio is altered in a way that differs from the classical mean–variance setting. A complete solution to the optimal portfolio in the presence of a risk-free asset is also provided.

PÉZIER, J.; SCHELLER, J. *Best portfolio insurance for long-term investment strategies in realistic conditions*. 263–274. Constant proportion portfolio insurance (CPPI) strategies implemented in continuous time on asset prices following geometric Brownian processes are expected utility maximising for investors with HARA utilities. But, in reality, these strategies are implemented in discrete time and asset prices might jump. We show that under these more realistic circumstances, optimal CPPI strategies are still superior to optimal option based portfolio insurance (OBPI) strategies. The effects of discrete replication and jumps on optimal strategy parameters and certainty equivalent returns (CER) are examined by simulation and turn out to be minor in typical circumstances. Hence the much discussed gap risks are unimportant for investors in both portfolio insurance strategies and comparable for insurers of the gap risks.

PITSELIS, G. *Pure robust versus robust portfolio unbiased — Credibility and asymptotic optimality*. 391–403. Empirical credibility estimation, which is a credibility counterpart of empirical Bayes estimation, lacks robustness due to the sensitivity of estimators to outlier events. In this paper we combine robust statistics with empirical linear Bayes estimation and derive robust asymptotic optimality based on Norberg's (1980) proposal. Robust portfolio-unbiased empirical regression credibility is derived and its asymptotic optimality is proved, under not very restrictive assumptions. The asymptotic optimality of pure robust credibility estimators is also proved.

The superiority of the pure robust credibility estimation against the robust portfolio-unbiased credibility estimation is presented and verified with numerical results.

SINGOR, S. N.; GRZELAK, L.; VAN BRAGT, D.; OOSTERLEE, C. W. *Pricing inflation products with stochastic volatility and stochastic interest rates.* 286–299. We consider a Heston type inflation model in combination with a Hull–White model for nominal and real interest rates, in which all the correlations can be non-zero. Due to the presence of the Heston dynamics our derived inflation model is able to capture the implied volatility skew/smile, which is present in the inflation option market data. We derive an efficient approximate semi-closed pricing formula for two types of inflation dependent options: index and year-on-year inflation options. The derived pricing formulas allow for an efficient calibration of the inflation model. We also illustrate our approach using a real-life pension fund example, where the Heston Hull–White model is used to determine the value of conditional future indexations.

WONG, M. H.; ZHANG, S. *Computing best bounds for nonlinear risk measures with partial information.* 204–212. Extreme events occur rarely, but these are often the circumstances where an insurance coverage is demanded. Given the first, say, n moments of the risk(s) of the events, one is able to compute or approximate the tight bounds for risk measures in the form of E((x)) through semidefinite programmings (SDP), via distributional robust optimization formulations. Existing results in the literature have already demonstrated the power of this technique when (x) is linear or piecewise linear. In this paper, we extend the technique in the case where (x) is a polynomial or fractional polynomial.

WOO, J.-K.; CHEUNG, E. C. K. *A note on discounted compound renewal sums under dependency.* 170–179. The paper considers a renewal risk process in which a given inter-arrival time possibly has an impact on the size of the resulting claim. Under a fairly general dependency structure which contains various well-known examples in the literature as special cases, recursive formulas for the moments of the discounted aggregate claims are derived using the techniques in Léveillé and Garrido [G. Léveillé, J. Garrido Recursive moments of compound renewal sums with discounted claims, Scandinavian Actuarial Journal, 2001(2): 98–110]. Simplifications arise in the case of a dependent renewal risk process under 'Erlang weights'. Numerical examples are given towards the end to illustrate the impact of dependency on the discounted aggregate claims.

WÜTHRICH, M. V. *Challenges with non-informative gamma priors in the Bayesian over-dispersed Poisson reserving model.* 352–358. Tables 2 and 3 in England et al. (2012) [P.D. England, R.J. Verrall, M.V. Wüthrich, Bayesian overdispersed Poisson model and the Bornhuetter–Ferguson claims reserving method, Annals of Actuarial Science (2012) 6(2): 258–283] raise the conjecture that the claims reserves in the Bayesian over-dispersed Poisson (BODP) model with non-informative gamma priors are equal to the claims reserves in the chain-ladder (CL) model (the small differences in the figures could be explained by simulation inaccuracy). We give a counter-example to this conjecture. Moreover, we show that, working with non-informative priors needs a lot of care because a naïve treatment may lead to improper posterior distributions.

YANG, S. S.; DAI, T.-S. *A flexible tree for evaluating guaranteed minimum withdrawal benefits under deferred life annuity contracts with various provisions.* 231–242. Valuing guaranteed minimum withdrawal benefit (GMWB) has attracted significant attention from both the academic field and real world financial markets. However, some popular provisions of GMWB contracts, like the deferred life annuity structure, rollup interest rate guarantees, and surrender

options are hard to be evaluated analytically and are rarely addressed in the academic literature. This paper proposes a flexible tree model that can accurately evaluate the values and the fair insurance fees of GMWBs. The flexibility of our tree allows us to faithfully implement the aforementioned provisions without introducing significant numerical pricing errors. The mortality risk can also be easily incorporated into our pricing model. Our numerical results verify the robustness of our tree and demonstrate how the aforementioned provisions and the mortality risk significantly influence the values and the fair insurance fees of GMWBs.

YANG, S. S.; WANG, C.-W. *Pricing and securitization of multi-country longevity risk with mortality dependence.* 157–169. To deal with multi-country longevity risk, this article investigates the long-run equilibrium of mortality rates and introduces mortality correlations across countries as a means for pricing a multi-country longevity bond. The examination of the long-run equilibrium of the mortality rate relies on co-integration analysis, and a vector error correction model (VECM) is proposed for mortality forecasts. Mortality correlations among different countries under a VECM model are then derived. We take into account the mortality correlations across countries and utilize the multivariate Wang transform to derive the valuation formula for pricing the longevity bonds, with payoffs based on a combined weighted mortality index. This study illustrates the pattern of mortality correlations for men and women in the US and the UK, according to the Human Mortality Database. Our results show that mortality correlations across countries have a significant impact on pricing longevity bonds.

YANG, Y.; HASHORVA, E. *Extremes and products of multivariate AC-product risks.* 312–319. With motivation from Tang et al. (2011) [Q Tang, R Vernic, Z Yuan, The finite-time ruin probability in the presence of dependent extremal insurance and financial risks. 2011], in this paper we consider a tractable multivariate risk structure which includes the Sarmanov dependence structure as a special case. We derive several asymptotic results for both the sum and the product of such risk and then present three applications related to actuarial mathematics.

ZIVEYI, J.; BLACKBURN, C.; SHERRIS, M. *Pricing European options on deferred annuities.* 300–311. This paper considers the pricing of European call options written on pure endowment and deferred life annuity contracts, also known as guaranteed annuity options. These contracts provide a guaranteed value at the maturity of the option. The contract valuation is dependent on the stochastic interest rate and mortality processes. We assume single-factor stochastic square-root processes for both the interest rate and mortality intensity, with mortality being a time-inhomogeneous process. We then derive the pricing partial differential equation (PDE) and the corresponding transition density PDE for options written on the pure endowment and deferred annuity contracts. The general solution of the pricing PDE is derived as a function of the transition density function. We solve the transition density PDE by first transforming it to a system of characteristic PDEs using Laplace transform techniques and then applying the method of characteristics. Once an explicit expression for the density function is found, we then use sparse grid quadrature techniques to generate European call option prices on the pure endowment and deferred annuity contracts. This approach can easily be generalised to other contracts which are driven by similar stochastic processes presented in this paper. We test the sensitivity of the option prices by varying independent parameters in our model. As option maturity increases, the corresponding option prices significantly increase. The effect of mispricing the guaranteed annuity value is analysed, as is the benefit of replacing the whole-life annuity with a term annuity to remove volatility of the old age population.

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BOYER, M. M.; JACQUIER, E.; VAN NORDEN, S. *Are underwriting cycles real and forecastable?* 995–1015. Speculative efficiency often requires that future changes in a series cannot be forecast. In contrast, series with a cyclical component would seem to be forecastable with decreases, possibly relative to a trend, during the upper part of the cycle and increases during the lower part. On the basis of autoregressive model (AR) estimates, it is considered that there is strong evidence of cycles in insurance underwriting performance as measured by the premium-to-loss ratio. Indeed, a large literature attempts to explain this documented cyclicality. First, we show that the parameter estimates from AR models do not lead to any such inference and that in the contrary, the evidence in the data is consistent with no cyclicality at all. Second, we show that a number of different filters lead to the same conclusion: that there is no evidence of in-sample or out-of-sample predictability in annual insurance underwriting performance in the United States.

BOYLE, P.; KIM, J. H. T. *Designing a countercyclical insurance program for systemic risk.* 963–993. This article proposes a framework for measuring and managing systemic risk. Current solvency regulations have been criticized for their focus on individual firms rather than the system as a whole. We show how an insurance program can be designed to deal with systemic risk through a risk charge on participating institutions. The risk charge is based on the generalized co-conditional tail expectation, a conditional risk measure adapted from conditional value-at-risk. Current regulations have been criticized on the grounds that their capital requirements are procyclical. They require extra capital in periods of extreme stress thus exacerbating a crisis. We show how to construct a countercyclical risk charge and illustrate the approach using a numerical example.

COLE, C. R.; FERGUSON, W. L.; LEE, R. B.; MCCULLOUGH, K. A. *Internationalization in the reinsurance industry: an analysis of the net financial position of US reinsurers.* 897–930. In today's global marketplace, the extent of internationalization has become increasingly relevant. We use the framework of the eclectic paradigm to empirically investigate internationalization by U.S. reinsurers using the net financial position in foreign markets to proxy for the level of internationalization. Our sample includes both developed and developing nations to provide a more complete analysis of internationalization of U.S. reinsurers. We find that the factors related to reinsurers' net financial positions vary based on the characteristics of the countries, the reinsurers, and the industry.

FIELDS, L. P.; GUPTA, M.; PRAKASH, P. *Risk taking and performance of public insurers: an international comparison.* 931–962. We investigate how investor protection, government quality, and contract enforcement affect risk taking and performance of insurance companies from around the world. We find that better investor protection results in less risk taking, as do higher quality government and greater contract enforceability. However, we find only limited evidence that these factors influence firm performance. We conclude that better overall operating environments result in less risk taking by insurers without the concomitant decline in performance. These results imply that

better investor protection environments benefit policyholders and outside stockholders by preventing corporate insiders from expropriating wealth from policyholders and outside stockholders.

LIAN, Q.; SCHLESINGER, H. *Insurance contract design when the insurer has private information on loss size.* 1039–1050. This article examines the optimal indemnity contract in an insurance market, when the insurer has private information about the size of an insurable loss. Both parties know whether or not a loss occurred, but only the insurer knows the true value of the loss and/or to what extent the losses are covered under the policy. The insured may verify the insurer's loss estimate for a fixed auditing cost. The optimal contract reimburses the auditing costs in addition to full insurance for losses less than some endogenous limit. For losses exceeding this limit, the contract pays a fixed indemnity and requires no monitoring. The optimal contract is compared with the contracts obtained in cases where it is only the insured who can observe the loss size.

MCSHANE, M. K.; COX, LARRY A.; GE, Y. *Early mover advantages: evidence from the long-term care insurance market.* 1115–1141. Researchers frequently question whether financial firms benefit by developing new products because barriers to entry common to other industries generally do not exist. Studies of early mover advantages for new financial products provide mixed evidence at best. We find evidence of early mover advantages in the relatively young market for long-term care insurance (LTCI) using data that allow broad testing of financial performance. Product differentiation, individual lines exposure, firm size, and traditional health insurance experience also affect financial performance.

ROWELL, D.; CONNELLY, L. B. *A history of the term "moral hazard"* 1051–1075. The term "moral hazard" when interpreted literally has a strong rhetorical tone, which has been used by stakeholders to influence public attitudes to insurance. In contrast, economists have treated moral hazard as an idiom that has little, if anything, to do with morality. This article traces the genesis of moral hazard, by identifying salient changes in economic thought, which are identified within the medieval theological and probability literatures. The focus then shifts to compare and contrast the predominantly, normative conception of moral hazard found within the insurance-industry literature with the largely positive interpretations found within the economic literature.

SEOG, S. H. *Moral hazard and health insurance when treatment is preventive.* 1017–1038. We consider a two-period model under moral hazard when treatment is preventive. In the second period, the treatment level under moral hazard is higher than that under no moral hazard. However, it may be lower than that under moral hazard when overinsurance is not allowed. In the first period, the treatment level is higher when treatment is preventive than when it is not. Treatment level is also higher as the discount factor increases. We demonstrate that a treatment increase following a coverage increase does not necessarily imply moral hazard. These findings imply that moral hazard is possibly overemphasized in the literature.

SHI, P.; ZHANG, W.; VALDEZ, E. A. *Testing adverse selection with two-dimensional information: Evidence from the Singapore auto insurance market.* 1077–1114. This article examines adverse selection in insurance markets with two-dimensional information: policyholders' riskiness and degree of risk aversion. We build a theoretical model to make equilibrium predictions on competitive insurance screening. We study several variations on the pattern of information asymmetry. The outcomes range from full separation to partial separation, and complete pooling of risk types. Next, we propose a copula approach to jointly examine policyholders' coverage

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choice and accident occurrence in the Singapore automobile insurance market. Furthermore, we invoke the theory to identify subgroups of policyholders for whom one may expect the risk–coverage correlation and adverse selection to arise.

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AI, J.; BROCKETT, P. L.; GOLDEN, L. L.; GUILLÉN, M. *A robust unsupervised method for fraud rate estimation.* 121–143. If one is interested in managing fraud, one must measure the fraud rate to be able to assess the degree of the problem and the effectiveness of the fraud management technique. This article offers a robust new method for estimating fraud rate, PRIDIT-FRE (PRIDIT-based Fraud Rate Estimation), developed based on PRIDIT, an unsupervised fraud detection method to assess individual claim fraud suspiciousness. PRIDIT-FRE presents the first nonparametric unsupervised estimator of the actual rate of fraud in a population of claims, robust to the bias contained in an audited sample (arising from the quality or individual hubris of an auditor or investigator, or the natural data-gathering process through claims adjusting). PRIDIT-FRE exploits the internal consistency of fraud predictors and makes use of a small audited sample or an unaudited sample only. Using two insurance fraud data sets with different characteristics, we illustrate the effectiveness of PRIDIT-FRE and examine its robustness in varying scenarios.

BORN, P. H.; KLIMASZEWSKI-BLETTNER, B. *Should I stay or should I go?: The impact of natural disasters and regulation on U.S. property insurers' supply decisions.* 1–36. In this article, we identify the main factors that drive insurers' willingness to offer coverage in catastrophe-prone property insurance lines. We compare insurers' supply decisions in personal and commercial lines, with an emphasis on insurers' responses in the aftermath of natural disasters. Our empirical results suggest important policy implications with regard to improving the availability of insurance against catastrophic threats. Concerning the impact of regulatory constraints, we present empirical evidence that certain regulatory responses may unintentionally impede insurers' willingness to provide coverage against natural disasters.

BOULATOV, A.; DIECKMANN, S. *The risk-sharing implications of disaster insurance funds.* 37–64. We study the risk-sharing implications that arise from introducing a disaster insurance fund to the cat insurance market. Such a form of intervention can increase efficiency in the private market, and our design of disaster insurance suggests a prominent role of catastrophe reinsurance. The model predicts buyers will increase their demand in the private market, and the seller will lower prices to such an extent that their revenues decrease upon introduction of disaster insurance. We test two predictions in the context of the Terrorism Risk Insurance Act (TRIA). It is already known that the introduction of TRIA led to negative abnormal returns in the insurance industry. In addition, we show this negative effect is stronger for larger and for low-risk-averse firms—two results that are consistent with our model. The seller's risk aversion plays an important role in quantifying such feedback effects, and we point toward possible distortions in which a firm may even be overhedged upon introduction of disaster insurance.

CAI, J.; FANG, Y.; LI, Z.; WILLMOT, G. E. *Optimal reciprocal reinsurance treaties under the joint survival probability and the joint profitable probability.* 145–168. A reinsurance treaty involves

two parties, an insurer and a reinsurer. The two parties have conflicting interests. Most existing optimal reinsurance treaties only consider the interest of one party. In this article, we consider the interests of both insurers and reinsurers and study the joint survival and profitable probabilities of insurers and reinsurers. We design the optimal reinsurance contracts that maximize the joint survival probability and the joint profitable probability. We first establish sufficient and necessary conditions for the existence of the optimal reinsurance retentions for the quota-share reinsurance and the stop-loss reinsurance under expected value reinsurance premium principle. We then derive sufficient conditions for the existence of the optimal reinsurance treaties in a wide class of reinsurance policies and under a general reinsurance premium principle. These conditions enable one to design optimal reinsurance contracts in different forms and under different premium principles. As applications, we design an optimal reinsurance contract in the form of a quota-share reinsurance under the variance principle and an optimal reinsurance treaty in the form of a limited stop-loss reinsurance under the expected value principle.

CANNON, E.; TONKS, I. *The value and risk of defined contribution pension schemes: International evidence.* 95–119. We use historical data on investment returns and labor income from 16 countries to quantify the value and risk of defined contribution pension plans, building frequency distributions of pension fund and pension replacement ratios for each country. We show that pension risk is substantial and find that pension fund ratios are lower and less variable than when the correlation between wage growth and investment returns is ignored, typically halving the median pension fund ratio. We also show that an all-equity fund is the dominant investment strategy across all countries, although sometimes a life-cycle strategy insures against downside risk.

CHANTARAT, S.; MUDE, A. G.; BARRETT, C. B.; CARTER, M. R. *Designing index-based livestock insurance for managing asset risk in Northern Kenya.* 205–237. This article describes a novel index-based livestock insurance (IBLI) product piloted among pastoralists in Northern Kenya, where insurance markets are effectively absent and uninsured risk exposure is a main cause of poverty. We describe the methodology used to design the contract and its underlying index of predicted area-average livestock mortality, established statistically using longitudinal observations of household-level herd mortality fit to remotely sensed vegetation data. Household-level performance analysis based on simulations finds that IBLI removes 25–40 percent of total livestock mortality risk. We describe the contract pricing and the risk exposures of the underwriter to establish IBLI's reinsurability on international markets.

HO, C.-L.; LAI, G. C.; LEE, J.-P. *Organizational structure, board composition, and risk taking in the U.S. Property casualty insurance industry.* 169–203. This study examines the impact of organizational structure and board composition on risk taking in the U.S. property casualty insurance industry, addressing different risk-taking behaviors from different perspectives. The risk-taking measures include total risk, underwriting risk, investment risk, and leverage risk. The evidence shows that mutual insurers have lower total risk, underwriting risk, and investment risk than stock insurers. In terms of board composition variables, we find that some board composition variables not only have impact on risk-taking behaviors but also affect different risk measures differently. Thus, using different risk measures is better than using one risk measure to assess risk-taking behavior. Finally, we conclude that an insurer can control its total risk through management of underwriting, investment, and leverage risks that determine an insurer's risk profile.

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THOMANN, C. *The impact of catastrophes on insurer stock volatility.* 65–94. This article investigates the impact of natural catastrophes and the 9-11 attacks on (1) the volatility of insurance stocks and (2) the correlation of insurance stocks with the market. We find that natural catastrophes increase the volatility of insurance stocks. They also have a tendency to reduce the correlation of insurance stocks and the market. Investors can, consequently, diversify natural catastrophe risk by additionally holdings of a market portfolio. However, this does not hold for 9-11. The events of 9-11 led to increases in volatility and, simultaneously, to an increase in correlation. We also find evidence that 9-11 increased the beta of insurance stocks.

North American Actuarial Journal

16 (4), 2012

DE CARVALHO, M.; MARQUES, F. J. *Jackknife Euclidean likelihood-based inference for Spearman's Rho.* 487–492. We discuss jackknife Euclidean likelihood-based inference methods, with a special focus on the construction of confidence intervals for Spearman's rho. We show that a Wilks' theorem holds for jackknife Euclidean likelihood, and based on it we construct confidence intervals for Spearman's rho. In a simulation study we examine the performance of our method, and a fire insurance claims database is used for its illustration.

GATZERT, N.; SCHMITT-HOERMANN, G.; SCHMEISER, H. *Optimal risk classification with an application to substandard annuities.* 462–486. Substandard annuities pay higher pensions to individuals with impaired health and thus require special underwriting of applicants. Although such risk classification can substantially increase a company's profitability, these products are uncommon except for the well-established U.K. market. In this paper we comprehensively analyze this issue and make several contributions to the literature. First, we describe enhanced, impaired life, and care annuities, and then we discuss the under writing process and underwriting risk related thereto. Second, we propose a theoretical model to determine the optimal profit-maximizing risk classification system for substandard annuities. Based on the model framework and for given price-demand dependencies, we formally show the effect of classification costs and costs of underwriting risk on profitability for insurers. Risk classes are distinguished by the average mortality of contained insureds, whereby mortality heterogeneity is included by means of a frailty model. Third, we discuss key aspects regarding a practical implementation of our model as well as possible market entry barriers for substandard annuity providers.

KHORASANEE, M. Z. *Risk-sharing and benefit smoothing in a hybrid pension plan.* 449–461. A hybrid pension plan with an explicit formula for sharing risk between the plan sponsor and the members is proposed. The performance of this plan is analyzed using a modified version of the model used by Dufresne (1988). Formulae for the variance of the contribution income and benefit outgo are derived, assuming investment returns are independent and identically distributed. The performance of the hybrid plan is compared with a defined-contribution (DC) plan providing the same expected retirement benefit. It is shown that the hybrid plan is more

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efficient in the control of investment risk, and that this gain in efficiency is greater when "lifestyle" investment strategies are adopted in the DC plan. Modifications to the proposed hybrid benefit structure that might be required for a real plan are suggested.

MISHURA, Y.; SCHMIDLI, H. *Dividend barrier strategies in a renewal risk model with generalized erlang interarrival times*. 493–512. We consider a renewal risk model with generalized Erlang distributed interarrival times. We assume that the phases of the interarrival time can be observed. In order to solve de Finetti's dividend problem, we first consider phasewise barrier strategies and look for the optimal barriers when the initial capital is 0. For exponentially distributed claim sizes, we show that the barrier strategy is optimal among all admissible strategies. For the special case of Erlang(2) interarrival times, we calculate the value function and the optimal barriers.

YANG, S.-Y.; HWANG, Y.-W.; CHANG, S.-C. B. *The bankruptcy cost of the life insurance industry under regulatory forbearance: An embedded option approach*. 513–523. In this study the Taiwan Insurance Guaranty Fund (TIGF) is introduced to investigate the ex-ante assessment insurance guaranty scheme. We study the bankruptcy cost when a financially troubled life insurer is taken over by TIGF. The pricing formula of the fair premium of TIGF incorporating the regulatory forbearance is derived. The embedded Parisian option due to regulatory forbearance on fair premiums is investigated. The numerical results show that leverage ratio, asset volatility, grace period, and intervention criterion influence the default costs. Asset volatility has a significant effect on the default option, while leverage ratio is shown to aggravate the negative influence from the volatility of risky asset. Furthermore, the numerical analysis concludes that the premium for the insurance guaranty fund is risk sensitive and that a risk-based premium scheme could be implemented, hence, to ease the moral hazard.

YASHIN, A. I.; ARBEEV, K. G.; UKRAINTSEVA, S. V.; AKUSHEVICH, I.; KULMINSKI, A. *Patterns of aging-related changes on the way to 100: An approach to studying aging, mortality and longevity from longitudinal data*. 403–433. The objective of this paper is to investigate dynamic properties of age trajectories of physiological indices and their effects on mortality risk and longevity using longitudinal data on more than 5,000 individuals collected in biennial examinations of the Framingham Heart Study (FHS) original cohort during about 50 subsequent years of follow-up. We first performed empirical analyses of the FHS longitudinal data. We evaluated average age trajectories of indices describing physiological states for different groups of individuals and established their connections with mortality risk. These indices include body mass index, diastolic blood pressure, pulse pressure, pulse rate, level of blood glucose, hematocrit, and serum cholesterol. To be able to investigate dynamic mechanisms responsible for changes in the aging human organisms using available longitudinal data, we further developed a stochastic process model of human mortality and aging, by including in it the notions of "physiological norms," "allostatic adaptation and allostatic load," "stress resistance," and other characteristics associated with the internal process of aging and the effects of external disturbances. In this model, the persistent deviation of physiological indices from their normal values contributes to an increase in morbidity and mortality risks. We used the stochastic process model in the statistical analyses of longitudinal FHS data. We found that different indices have different average age patterns and different dynamic properties. We also found that age trajectories of long-lived individuals differ from those of the shorter-lived members of the FHS original cohort for both sexes. Using methods of statistical modeling, we evaluated "normal" age trajectories of physiological indices and the dynamic effects of allostatic adaptation. The model

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allows for evaluating average patterns of aging-related decline in stress resistance. This effect is captured by the narrowing of the U-shaped mortality risk (considered a function of physiological state) with age. We showed that individual indices and their rates of change with age, as well as other measures of individual variability, manifested during the life course are important contributors to mortality risks. The advantages and limitations of the approach are discussed.

YUE, J. C. *Mortality compression and longevity risk*. 434–448. In this study, we explore the increasing life expectancy by examining the basic properties of survival curves. Specifically, we check if there are signs of mortality compression (i.e., rectangularization of the survival curve) and evaluate what it means to designing annuity products. Based on the raw mortality rates, we propose an approach to verify if there is mortality compression. We then apply the proposed method to the mortality rates of Japan, Sweden and the United States (data source: Human Mortality Database). Unlike the previous results using the graduated mortality rates, we found there are no obvious signs that mortality improvements are slowing down. This indicates that human longevity is likely to increase and longevity risk should be seriously considered in pricing annuity products.

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Scandinavian Actuarial Journal

4, 2012

CZADO, C.; KASTENMEIER, R.; BRECHMANN, E. C.; MIN, A. *A mixed copula model for insurance claims and claim sizes*. 278–305. A crucial assumption of the classical compound Poisson model of Lundberg for assessing the total loss incurred in an insurance portfolio is the independence between the occurrence of a claim and its claims size. In this paper we present a mixed copula approach suggested by Song et al. to allow for dependency between the number of claims and its corresponding average claim size using a Gaussian copula. Marginally we permit for regression effects both on the number of incurred claims as well as its average claim size using generalized linear models. Parameters are estimated using adaptive versions of maximization by parts (MBP). The performance of the estimation procedure is validated in an extensive simulation study. Finally the method is applied to a portfolio of car insurance policies, indicating its superiority over the classical compound Poisson model.

GUILLÉN, M.; NIELSEN, J. P.; PEREZ-MARIN, A. M.; PETERSEN, K. S. *Performance measurement of pension strategies: a case study of Danish life cycle products*. 258–277. The Danish pension markets of life cycle products have expanded considerably since its introduction in the beginning of the millennium. The market is maturing and pensioners have the choice between a wide area of different products. It is therefore about time that financial insurance technology is developed to guide the performance measurement of available products. In this paper we develop a simple first version of such a method and we investigate life cycle products

recommended on the web of the four biggest commercial Danish pension companies on one day in February 2007. All considered products are outperformed by trivial benchmark products with constant stock proportion over time. Our approach is the following: for each life cycle product we first find a trivial benchmark product with the same long-term risk and then we compare the long-term return of the two equivalent products. We primarily consider value at risk and tail value at risk as risk measures, but we also include a study where the fair value of an interest guarantee is used as risk measure. We consider both long-term mean returns and long-term median returns. We hope that our new method will be regarded as a first step towards a scientifically based ranking of the quality of pension products.

RICHARDS, S. J. *A handbook of parametric survival models for actuarial use.* 233–257. Traditional actuarial techniques for mortality analysis are being supplanted by statistical models. Chief amongst these are survival models, which model mortality continuously at the level of the individual. An assumption of a mathematical form for the hazard function or, equivalently, the assumption of a continuous distribution for an individual's lifetime, leads automatically to smooth fitted mortality rates. This note gives an overview of the survival models commonly found in statistical packages and compares their suitability for actuarial work with the mortality 'laws' proposed by actuaries over the past two centuries. We find that the actuarial laws provide substantially better fits at post-retirement ages. We also give a common structure of parameterisation which gives consistent behaviour and interpretation of risk factors across all 16 survival models listed here. Finally, we consider the benefits of working directly with the log-likelihood function, including making allowance for the left truncation which is common for the data with which actuaries work.

Scandinavian Actuarial Journal

1, 2013

GUILLÉN, M.; NIELSEN, J. P.; PEREZ-MARIN, A. M.; PETERSEN, K. S. *Performance measurement of pension strategies: A case study of Danish life-cycle products.* 49–68. The Danish pension market of life-cycle products have expanded considerably since its introduction in the beginning of the millennium. The market is maturing and pensioners have the choice between a wide area of different products. It is therefore about time that financial insurance technology is developed to guide the performance measurement of available products. In this paper we develop a simple first version of such a method and we investigate life-cycle products recommended on the web of the four biggest commercial Danish pension companies on one day in February 2007. All considered products are outperformed by trivial benchmark products with constant stock proportion over time. Our approach is the following: for each life-cycle product we first find a trivial benchmark product with the same longterm risk and then we compare the long-term return of the two equivalent products. We primarily consider value at risk (VaR) and tail VaR as risk measures, but we also include a study where the fair value of an interest guarantee is used as risk measure. We consider both long-term mean returns and long-term median returns. We hope that our new method will be regarded as a first step toward a scientifically based ranking of the quality of pension products.

HASHORVA, E. *On beta-product convolutions.* 69–83. Let R be a positive random variable independent of S which is beta distributed. In this paper we are interested on the relation between

R and RS. For this model we derive first some distributional properties, and then investigate the lower tail asymptotics of RS when R is regularly varying at 0, and vice-versa. Our first application concerns the asymptotic behaviour of the componentwise sample minima related to elliptical distributions. Further, we derive the lower tail asymptotics of the aggregated risk for bivariate polar distributions.

MIERZEJEWSKI, F. *Raising and allocation capital principles as optimal managerial contracts.* 24–48. A unified framework is presented to characterise the capital structure of firms that face borrowing restrictions – which extends the classic theory of capital by incorporating elements from actuarial and agency theory. It is demonstrated that the bankruptcy and agency costs afforded by these firms can be expressed in terms of the actuarial prices of the underlying exposures. Then the optimal surplus is determined in order to maximise value – which is equivalent to minimise the cost of bankruptcy plus the opportunity cost of capital. The capital principle thus obtained explicitly depends on risk and expectations, and can be applied to allocate reserves both in financial and insurance companies. An optimal decentralised mechanism is also defined that stimulates the exchange of information inside multidivisional corporations.

ZHOU, R.; LIA, J. S.-H. *A cautionary note on pricing longevity index swaps.* 1–23. In December 2007, Goldman Sachs launched a product called QxX index swap, which is designed to allow market participants to hedge or gain exposure to longevity and mortality risks. In this paper, we offer a quantitative analysis of this brand new financial innovation. First of all, we set up a risk-neutral framework to price QxX index swaps. This framework, which is based on the dynamics of death rates under a two-factor stochastic mortality model in a risk-adjusted probability measure, yields prices (spreads) that are fairly close to the spreads that Goldman Sachs currently offers. We then explore the uncertainty involved in this model-based pricing framework. Specifically, we study parameter risk by using Bayesian methods and model risk by examining structural changes in mortality dynamics. Our results indicate that both model risk and parameter risk are significant. Actuaries should therefore be aware of these issues when placing a value on a longevity index swap.

Scandinavian Actuarial Journal

2, 2013

CASTAÑER, A.; CLARAMUNT, M. M.; GATHY, M.; LEFÈVRE, C.; MÁRMOL, M. *Ruin problems for a discrete time risk model with non-homogeneous conditions.* 83–102. This paper is concerned with a non-homogeneous discrete time risk model where premiums are fixed but non-uniform, and claim amounts are independent but non-stationary. It allows one to account for the influence of inflation and interest and the effect of variability in the claims. Our main purpose is to develop an algorithm for calculating the finite time ruin probabilities and the associated ruin severity distributions. The ruin probabilities are shown to rely on an underlying algebraic structure of Appell type. That property makes the computational method proposed quite simple and efficient. Its application is illustrated through some numerical examples of ruin problems. The well known Lundberg bound for ultimate ruin probabilities is also reexamined within such a non-homogeneous framework.

CHEUNG, K. C.; VANDUFFEL, S. *Bounds for sums of random variables when the marginal distributions and the variance of the sum are given.* 103–118. In this paper, we establish several

relations between convex order, variance order, and comonotonicity. In the first part, we extend Cheung (2008b) [Cheung, K. C. (2008b). Characterization of comonotonicity using convex order. Insurance: Mathematics and Economics 43, 403–406] to show that when the marginal distributions are fixed, a sum with maximal variance is in fact a comonotonic sum. Thus the convex upper bound is achieved if and only if the marginal variables are comonotonic. Next, we study the situation where besides the marginal distributions; the variance of the sum is also fixed. Intuitively one expects that adding this information may lead to a bound that is sharper than the comonotonic upper bound. However, we show that such upper bound does not even exist. Nevertheless, we can still identify a special dependence structure known as upper comonotonicity, in which case the sum behaves like a convex largest sum in the upper tail. Finally, we investigate when the convex order is equivalent to the weaker variance order. Throughout this paper, interpretations and significance of the results in terms of portfolio risks will be emphasized.

HUANG, H.-H.; SHIU, Y.-M.; WANG, C.-P. *Optimal insurance contract with stochastic background wealth*. 119–139. This study presents an optimal insurance contract developed endogenously when insured individuals face two mutually dependent risks, background wealth and insurable loss. If background wealth is conditionally normally distributed given insurable loss, the optimal insurance contract may be proportional coinsurance above a straight deductible for a quadratic, negative exponential, or mean-variance utility function. Additionally, when the insured has a quadratic utility or mean-variance utility, the optimal retained schedule is a function of conditional expected value of background wealth given insurable loss. Moreover, the optimal insurance contracts for quadratic and negative exponential utility functions need not to be mean-variance efficient, even when the conditional normal distribution is assumed. Finally, when a portfolio problem is considered, the calculation about the optimal insurance contract remains almost unchanged.

ZHU, J. *Optimal dividend control for a generalized risk model with investment incomes and debit interest*. 140–162. This paper investigates dividend optimization of an insurance corporation under a more realistic model, which takes into consideration refinancing or capital injections. The model follows the compound Poisson framework with credit interest for positive reserve and debit interest for negative reserve. Ruin occurs when the reserve drops below the critical value. The company controls the dividend pay-out dynamically with the objective to maximize the expected total discounted dividends until ruin. We show that the optimal strategy, is a band strategy and it is optimal to pay no dividends when the reserve is negative.

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Variance

6 (1), 2012

FREES, E. W.; MEYERS, G. G.; CUMMINGS, A. D. *Predictive modeling of multi-peril homeowners insurance*. 11–31. Predictive models are used by insurers for underwriting and ratemaking in personal lines insurance. Focusing on homeowners insurance, this paper examines many predictive generalized linear models, including those for pure premium (Tweedie), frequency (logistic) and severity (gamma). We compare predictions from models based on a single

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peril, or cause of loss, to those based on multiple perils. For multi-peril models, we introduce an instrumental variable approach to account for dependencies among perils. We calibrate these models using a database of detailed individual policyholder experience. To evaluate these many alternatives, we emphasize out-of-sample model comparisons. We utilize Gini indices for global comparisons of models and, for local comparisons, introduce nonparametric regression techniques. We find that using several different comparison approaches can help the actuary critically evaluate the effectiveness of alternative prediction procedures.

FU, L. *Optimal growth for P&C insurance companies.* 102–121. It is generally well established that new business produces higher loss and expense ratios and lower retention ratios than renewal business. Ironically, to add more new business, an insurer needs higher profitability in order to generate the additional capital needed to support its exposure growth. Irrational growth is one of the of reasons for the insolvencies of property and casualty insurance companies. This study presents a method to balance the opposing forces of growth and profitability. The proposed method is straightforward and can be effectively employed by property and casualty insurers in their strategic planning process.

HALLIWELL, L. J. *The mathematics of excess losses.* 32–47. After laying a fairly rigorous foundation for the mathematical treatment of excess losses, this paper shows that the excess-loss function is akin to the probability distribution of its loss. All the moments of the loss can be reclaimed from the excess-loss function, the variance being especially simple. Excess-loss mathematics is a powerful tool for pricing loss layers, as in reinsurance. In some settings it may be more powerful than standard probability techniques. An example featuring the mixed exponential distribution demonstrates this. Two appendices deal with Stieltjes integrals and with proofs of two findings about layered losses that are commonly known among reinsurance actuaries.

KHURY, C. K. *Empirical method-based aggregate loss distributions.* 78–101. This paper presents a methodology for constructing a deterministic approximation to the distribution of the outputs produced by the loss development method (also known as the chain-ladder method). The approximation distribution produced by this methodology is designed to meet a preset error tolerance condition. More specifically, each output of the loss development method, when compared to its corresponding approximation, meets the preset error tolerance. Ways to extend this methodology to the Bornhuetter-Ferguson and the Berquist-Sherman families of methods are described. The methodology is illustrated for a sample loss development history.

SCHMID, F. *The workers compensation tails.* 48–77. There is a dearth of public knowledge about the development patterns of mature workers compensation claims at the level of the aggregate loss triangle; this is because there are only a few loss triangles available for research that span the full lifetime of the cohort of claimants. Analysis of two very large triangles provided by SCF Arizona (indemnity) and SAIF Oregon (medical component of permanent disability claims) shows how the consumption of indemnity and medical services of a given cohort of claimants develops as this cohort ages and gradually dies off over the decades. For indemnity triangles, the decay rate of consumption correlates with the rate of mortality; for medical triangles, this rate of decay assumes a stationary, negative value after about 20 development years.

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